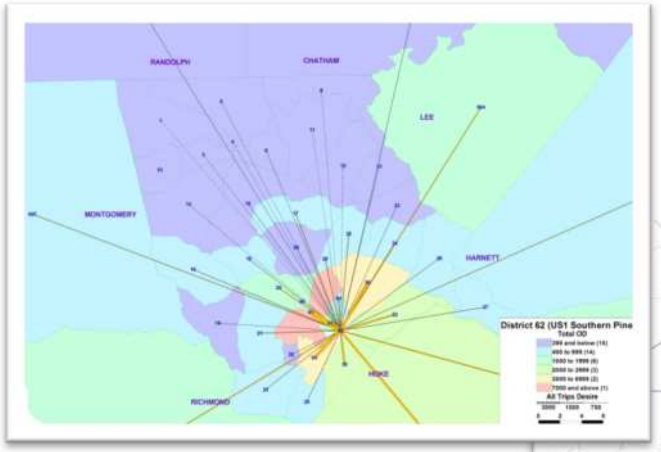
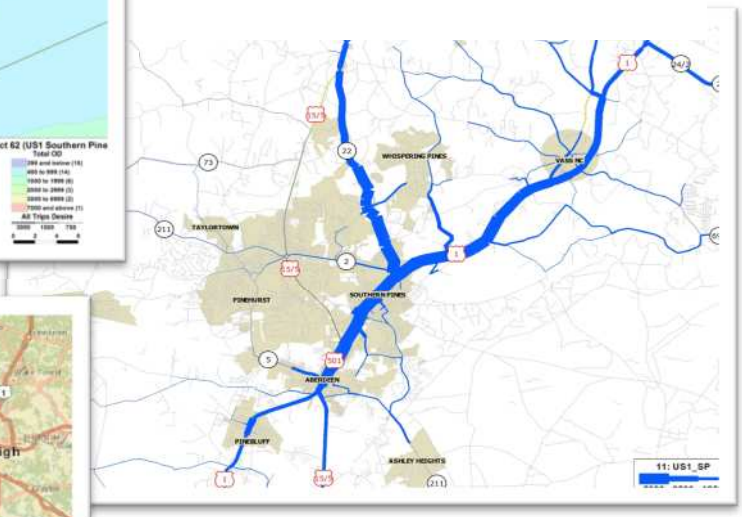
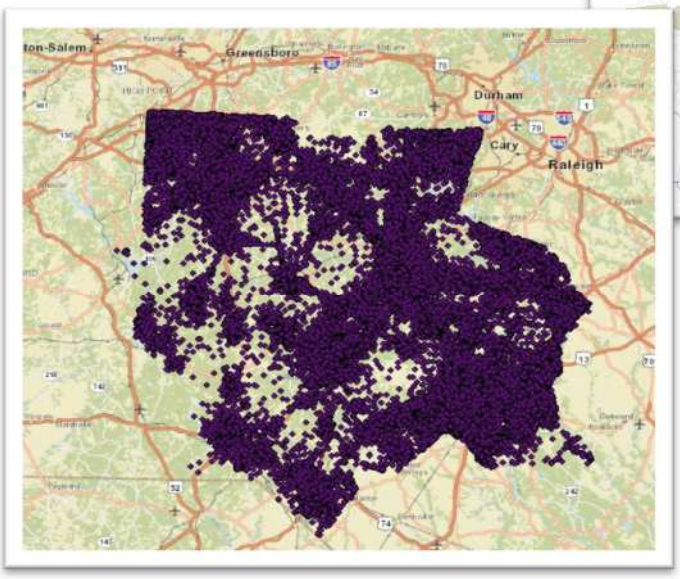
Origin Destination Analysis for Moore County, NC







For NCDOT & the Moore County Transportation Committee (MCTC)

Written By:
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July 31,2013

PARSONS BRINCKERHOFF

CLEARBOX

airsage

1.0 INTRODUCTION

In 2010, the Transportation Planning Branch (TPB), at the request of Moore County, initiated a collaborative process between the county, the Triangle Area Rural Planning Organization (TARPO), and NCDOT to develop a multimodal transportation plan that addressed the system needs of the county's transportation infrastructure through the year 2040. This is a vital step in aligning needed transportation projects with future funding through the state's project prioritization process.

During this process NCDOT received resolutions from Moore County specifically requesting the re-designation of the US 1 corridor from its future SHC designation of freeway to its current facility types and seven different cross-sections between the Towns of Vass and Pinebluff. In addition, the resolutions asked NCDOT to perform an Origin and Destination study and deemed consideration of any new location bypass east of US 1 in proximity to "Horse Country" as unacceptable to the local governments of Moore County. However, Richmond County, the Cities of Rockingham and Hamlet, as well as the Lumber River RPO to the south of Moore County responded with resolutions supporting the SHC vision of US 1 as a freeway.

It was important to NCDOT to answer the request made by the Moore County Transportation Committee (MCTC) and other Moore County stakeholders who felt it was imperative to better understand the travel patterns within and through the focus areas about which they, as representatives of those residents, could feel comfortable making decisions that would impact the County's transportation system and long-term transportation vision.

In July 2012, as part of the CTP study, NCDOT agreed to conduct an operational analysis of the corridor to evaluate other improvement alternatives that would meet the future mobility needs of US 1. In order, to be able to evaluate the base and future travel patterns of US 1 and all other roadways in Moore County, NCDOT decided to develop a travel demand model. The model allows for alternatives testing as it relates to travel flow in Moore County so that various project alternative scenarios can be evaluated. The model development process is still underway and will eventually include examination of impacts on a system-wide basis (locally, regionally, and statewide). Additionally, viable alternatives must be safe; provide effective access to and efficient passage through the county; accommodate future traffic; comply with state regulations for intrastate system facilities; and meet Federal requirements defined by the National Environmental Policy Act and processes.

NCDOT looked at various options for performing the Origin and Destination study including:

- **Automatic License Plate Recognition (ALPR) Cameras**- in which cameras are positioned at various locations across the county and license plates are matched to get flow patterns
- **Manual Roadside Interviews-** in which traffic is stopped along key roadway locations and questions asked about the trip being made at the time of the interview
- **Global Positioning System(GPS) Data-** using TomTom data provided by the GPS units travelers use in their vehicles as they make trips throughout the day.
- **Cellphone Data-** use of non-intrusive cell phone data to track travel patterns in the region.

It was decided that cell phone data seemed to be promising for the region because it allowed for:

- Un-intrusive data collection
- Unbiased travel flow data
- Exact time periods that coincided with the traffic count data being collected
- Trip purposes could be determined by time of day
- Could evaluate resident versus non-resident travel.

NCDOT and Parsons Brinckerhoff decided to use cell phone data to help inform the travel demand model but more importantly to understand the travel patterns in the Moore County region. Typically a household survey in which a sample of people in the region would record their travel patterns for one day during a week. Household surveys take an extensive effort to coordinate and often take a year to setup and complete. NCDOT did not have the resources and time to perform this type of survey and still provide the MCTC with timely information about their region. Although the cell phone data cannot currently replace the detailed household survey, it still provides information like trip purpose and the time of day that the trip was made and XY coordinates of the origins and destinations for a larger sample of households than the household survey would in the Moore County region.

Data was purchased from AirSage, an Atlanta based wireless information and data provider. They had developed a new approach to gathering data about population mobility throughout a region and had performed this analysis in several locations across the county. AirSage analyzes anonymous location and movement of mobile devices, which is derived from wireless signaling data from various cell phone providers, to provide new insights into where populations, are, were or will be, and how they move about over time.

The purpose of this document is to describe the methodology used by AirSage to determine Origin and Destinations (ODs) in the Moore County region and to explain the analysis performed on the OD data in order to understand the travel patterns in Moore County.

2.0 AirSage Technology

AirSage provides population location, movement, and traffic information derived from analysis of wireless (and in particular, cellular phone) signaling data. Combining patented and proprietary data collection and analysis technologies with signaling data from wireless carriers, AirSage has developed and deployed a secure data collection and reporting network with over 100 million mobile "sensors" that provide unprecedented visibility into where groups of people are, where they were, where they are likely to be, and how they move from one area to another.

AirSage's WiSE (Wireless Signal Extraction) technology extracts data from wireless carrier networks, as generated by devices in the normal course of operation. Mobile devices frequently communicate with the network through control channel messages, both during use and when the mobile is in idle mode. The frequency and nature of the signaling data varies based on the network equipment used to provide cellular service to the area. The WiSE technology anonymizes the data stream (ensuring user privacy) and performs multiple stages of analysis to monitor the location and movement of the mobile devices (and thus the population of mobile users). Figure 1 explains this in detail.

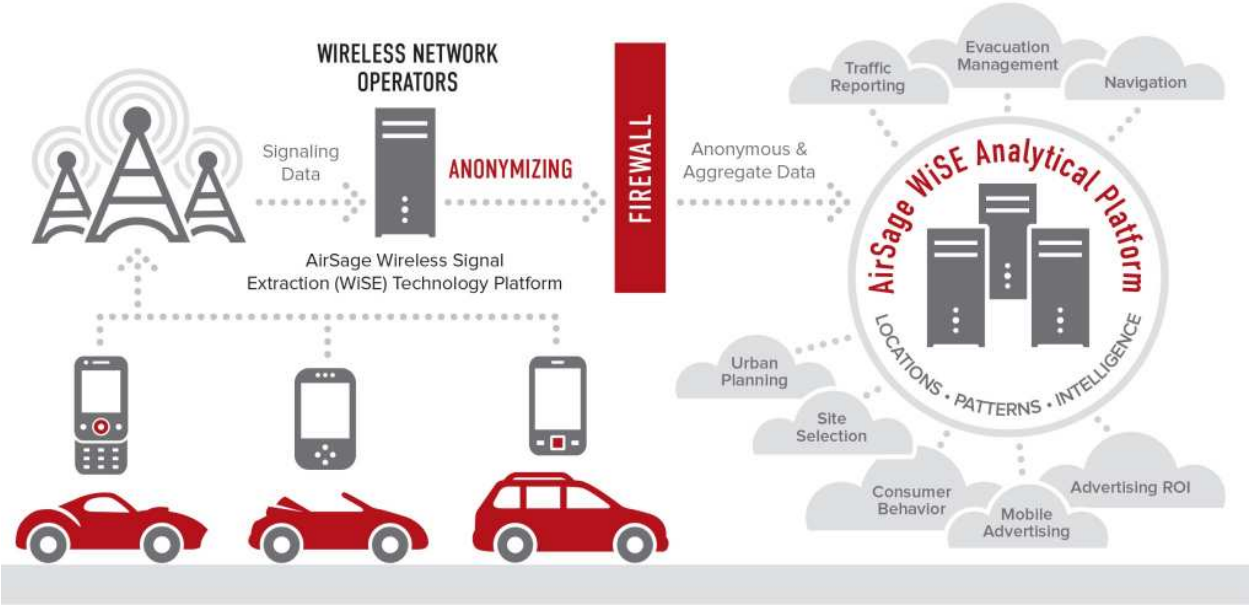


Figure 1: AirSage WiSE Technology

3.0 AirSage Study Methodology

AirSage uses a modular, multi-step methodology to derive useful information and analytics from wireless signaling data provided by its wireless carrier partners.

The core functional components are listed below, and further described throughout the remainder of this document.

AirSage PDE + Post-Process: Generates time-stamped locations (lat/long) for each mobile device (e.g. a cellphone), utilizing the network signaling data generated each time a mobile device interacts with the mobile network. Post-processing is applied to refine the raw location data, yielding Processed Sightings.

Activity Point Generation: Processed Sightings are grouped into uniform "grid cells" or "Grids" (rectangles typically 1000 meters on a side), which are the basic geographical unit used by AirSage to analyze movement of mobile devices over time (Figure 2). Collectively, a series of one or more time-consecutive sightings within a single Grid represent a single Activity Point. Additional attributes assigned to the Activity Point characterize the device's movement (or "Activity") relative to that Grid. For example, has the device just completed a trip? Is it just passing through?

TAZ Assignment: For each particular study, one or more Traffic Analysis Zones (TAZ) are defined by geographical boundaries that define a particular area (e.g. a neighborhood) or venue (e.g. a sports stadium, a park, etc.). In TAZ Assignment, each Activity Point is assigned to the TAZ that contains it as shown in Figure 3.

Data Expansion: Using several factors, such as the relative mobile device penetration of AirSage partner carriers vs. the full population, US Census data, visibility (subscriber sighting frequency), and others, the TAZ Count sample data is expanded to reflect the actual Trip Count that would be expected to be observed in the field (i.e. for the total population).

Post Analysis: To meet specific project requirements, additional analysis may be applied to further characterize the Trips to a given TAZ. Examples include Origin (determined using subscriber Home/Work Tables), visit duration (how long did a given Visitor dwell in the TAZ?), and visit frequency (over a given time period, how often did a given Visitor visit the TAZ?). The extent and granularity of these insights depends on a variety of factors including the time period studied, sample size relative to the universe of potential trips, and others.

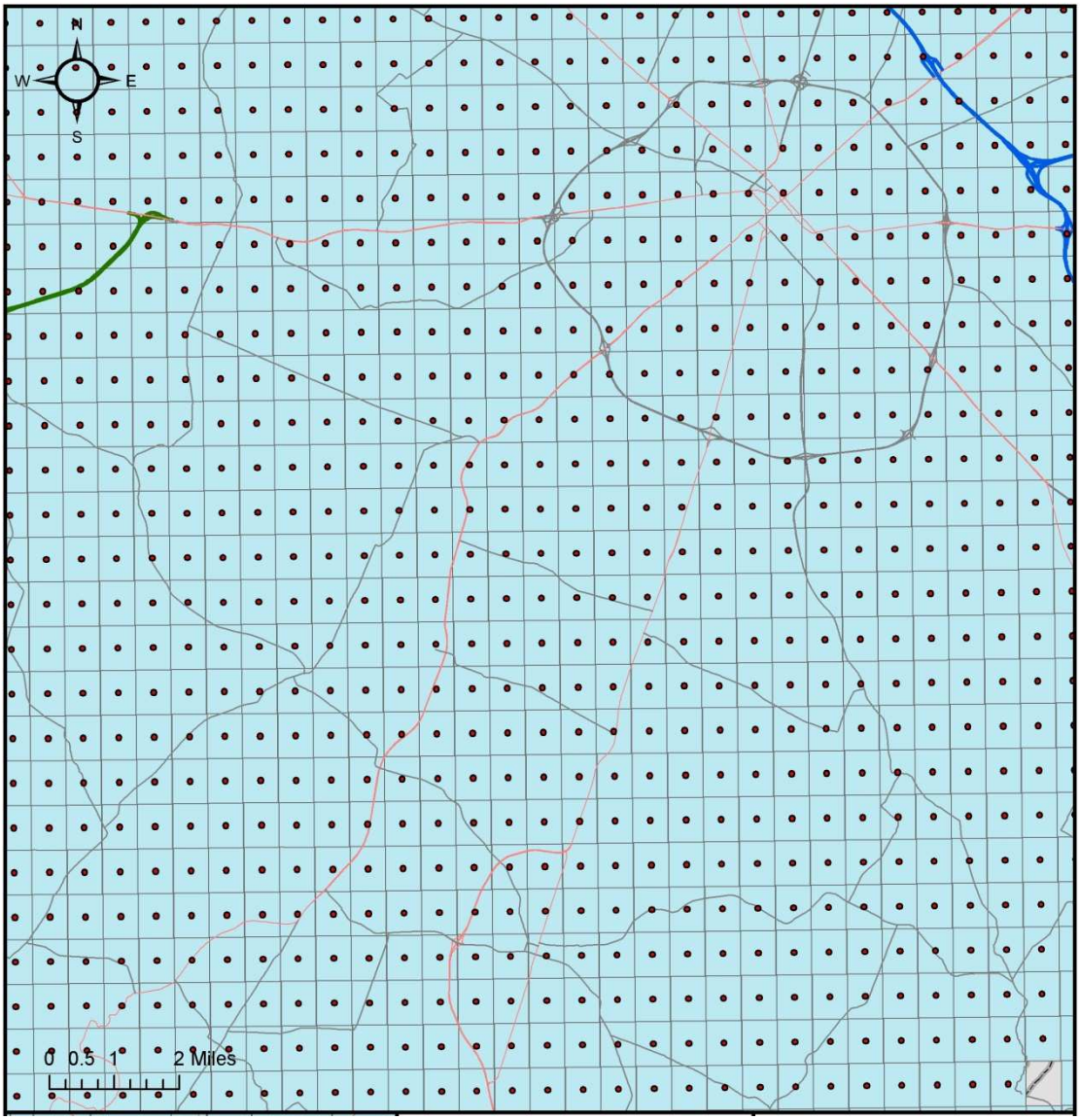


Figure 2: Example AirSage Grid Cell Map

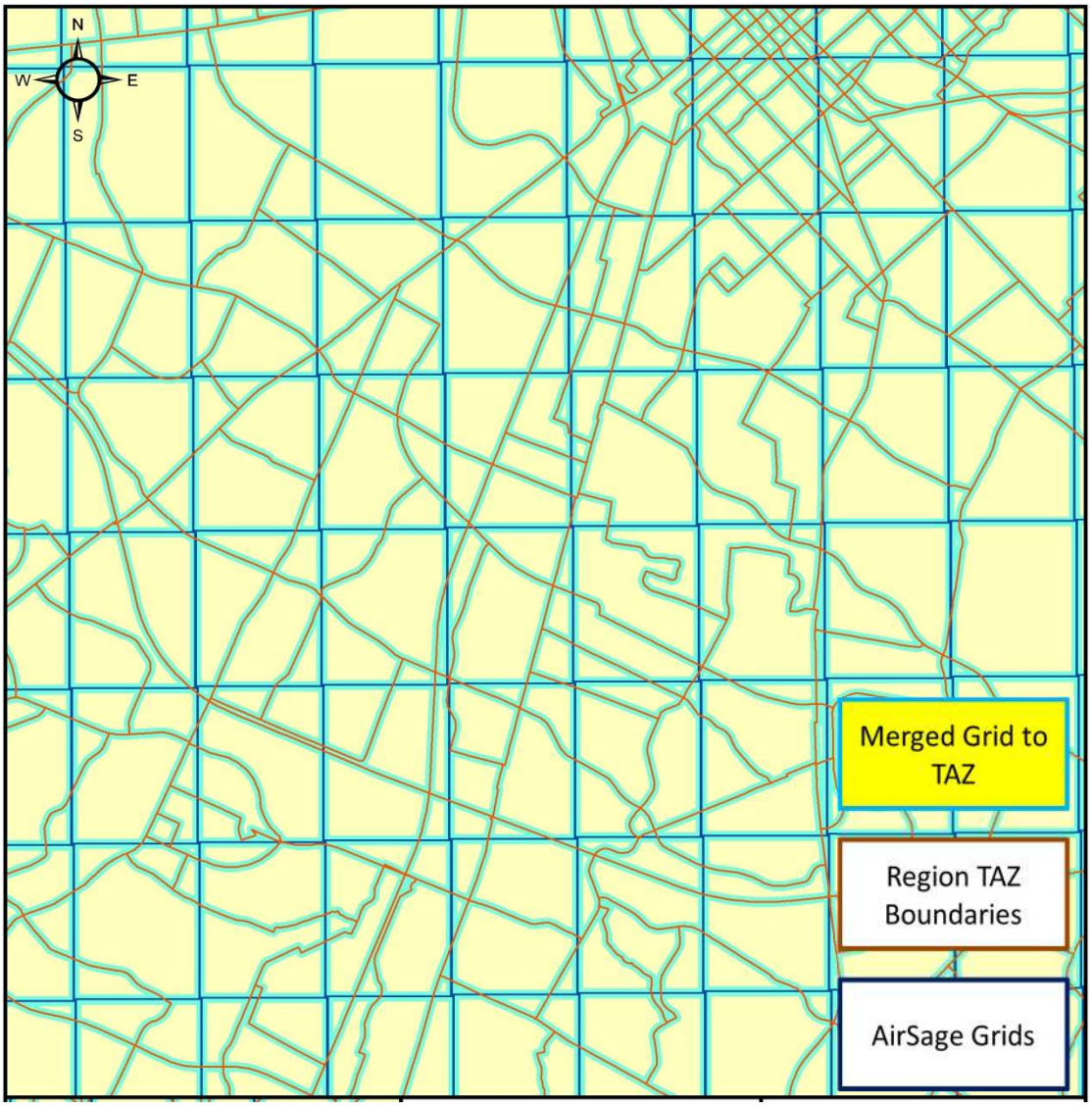


Figure 3: GIS Processing of Grid Assignment to the Region TAZs

4.0 ANALYSIS COMPONENTS

Each time a mobile device on one of AirSage's carrier partner networks engages with the network (e.g. to send or receive a call), AirSage receives network signaling data.

The role of the AirSage PDE (Position Determining Entity) is to analyze the signaling data, which includes data elements such as:

- Encrypted Device ID associated with the signaling data (i.e. an encrypted version of the mobile device's unique MEID).
- Cell tower(s) visible to the device when the network event occurred
- Other proprietary signal information

Using this data, the PDE uses advanced "triangulation" and other proprietary analysis to yield a time-stamped location (lat/long) – i.e. a Raw Sighting – for the encrypted Device ID. The PDE also provides additional data regarding the estimated accuracy and validity of each location.

PDE Data Output and Post-Processing

The raw time-stamped lat/long data output by the PDE is prone to small variances due to specific characteristics of the original network signaling data, or artifacts of the triangulation process itself.

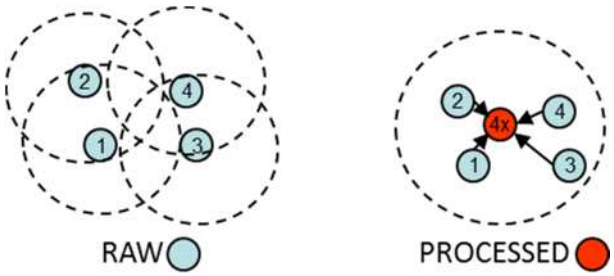


Fig. 2 – Removing spatial "jitter"

These variances are commonly seen as "spatial jitter," which occurs when a series of consecutive sightings from a mobile device which is actually stationary generate slightly different lat/long locations. See **Figure 2**. Noise reduction techniques are applied to converge these sightings onto a single lat/long point location, i.e. each of the sightings is assigned the same "converged" lat/long. The degree of noise reduction applied is based on the quality of the network signaling data, overall performance capabilities of the PDE, the relative time intervals between the Raw Sightings, and other factors.

Activity Points

Activity Points are thus comprised of time-adjacent Processed Sightings within a single Grid. When a device enters a new Grid, thus begins a new Activity Point.

A TAZ is simply a defined geographical boundary, usually associated with an area of interest (e.g. a neighborhood) or a business district (e.g. a sports stadium, a park, a retail location and surrounding buffer zone, etc.). TAZ definitions are typically provided via a GIS shapefile.

In TAZ Assignment, each Activity Point record is assigned, based on its Grid or raw location, to the TAZ boundary that contains that location.

This is necessary for efficient analysis of movement. In other words, an Activity Point indicates:

i) the mobile device was located in this TAZ,
ii) in this time window, and
iii) the device was either stationary or moving (or "uncertain") in this TAZ and time window.

Data Output

Because they encompass multiple Processed Sightings, the output for Activity Points includes time duration, i.e. the difference between when the device entered that Grid, and when it left the Grid. These durations can be quite long, for example, when the device goes home after work and remains there overnight.

While not required specifically to derive Trip Counts, additional attributes are assigned to the Activity Point to characterize the device's status or movement (i.e. "Activity") relative to that Grid. For example, has the device just completed a trip (i.e. an "End Point")? Is the device in motion, pasting through this Grid on the way to a different destination (i.e. a "Transient Point")?

Subscriber Visibility

Also generated with Activity Points are Subscriber Visibility statistics. These stats deal with how frequently (or not) a given mobile device is visible to AirSage during the course of a day. Visibility tables are generally built using 15-minute intervals. This information becomes an input for Data Expansion.

Subscriber Home & Work Assignments

Also generated with Activity Points are the Home and Work census block groups for each mobile device. These are determined by observing device movement patterns over time. The data processing to determine the home and work locations use the following assumptions:

- A 'home zone' is defined as being wherever a subscriber was during 'home time' for at least half the weekdays (20 for Moore County) during the study period. If over the majority of the period the same signal is received in the same grid then it is assumed to be the home location. 'home time' is typically defined as 9 PM to 7 AM.

- A 'work zone' is defined as being wherever subscriber was during 'work time' for at least half the weekdays (20 for Moore County) during the study period. 'work time' is typically defined as 9 AM to 4:00 PM.

In addition to determining the trip locations, it was important to understand if the trips being made were by residents of Moore County or by people who reside in other adjacent counties. This allows for understanding of the differences in travel patterns between residents and others. For this data residents are defined as having a 'home zone' inside of Moore County while non-Residents are defined as living outside Moore County(for example in Hoke and Lee Counties).

Figure 4 and Figure 5 show the Home and Work locations of the residents and non-residents in the Moore County Region.

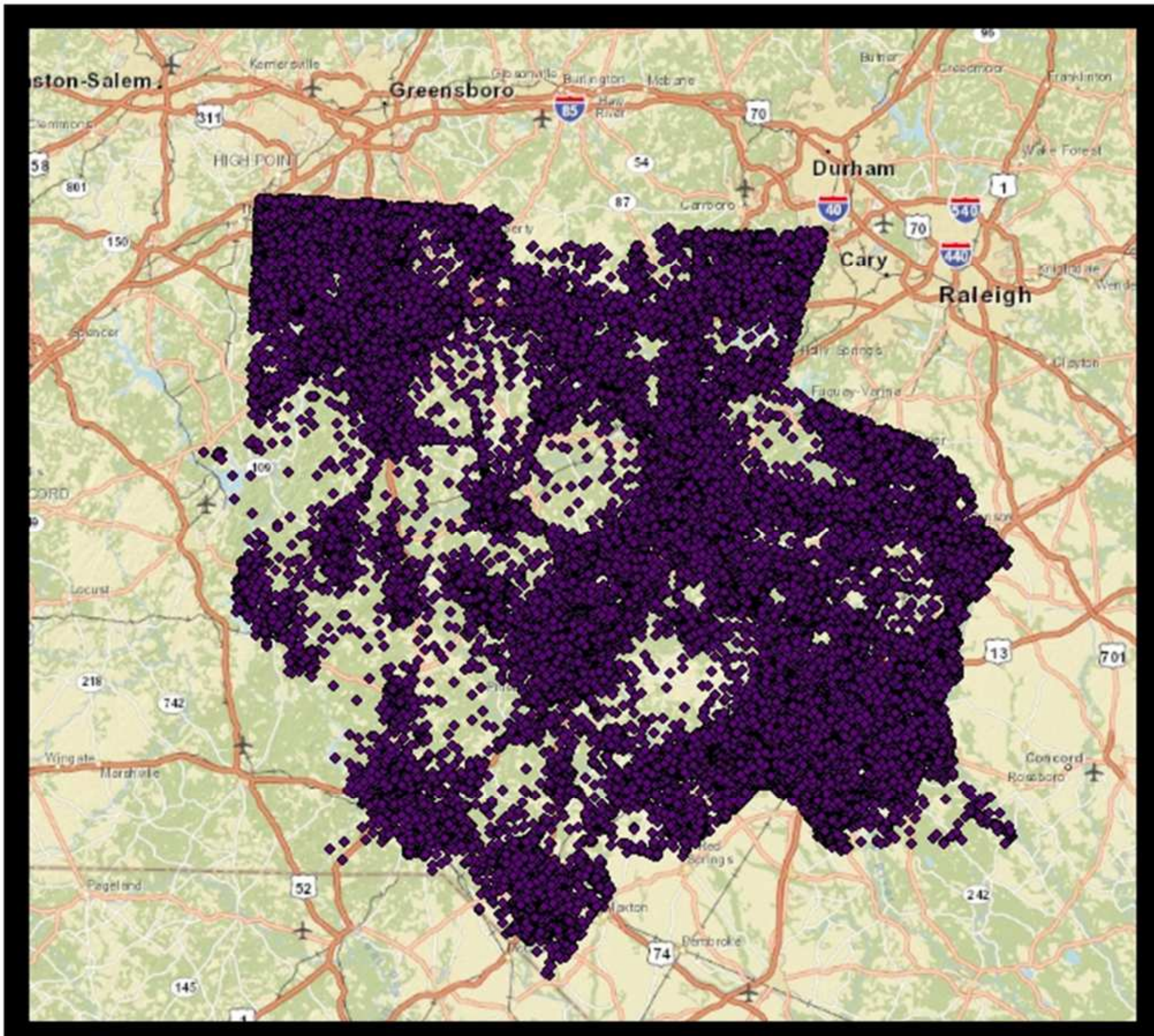


Figure 4: Home Locations in the Moore County Region (Residents and Non-Resident Locations)

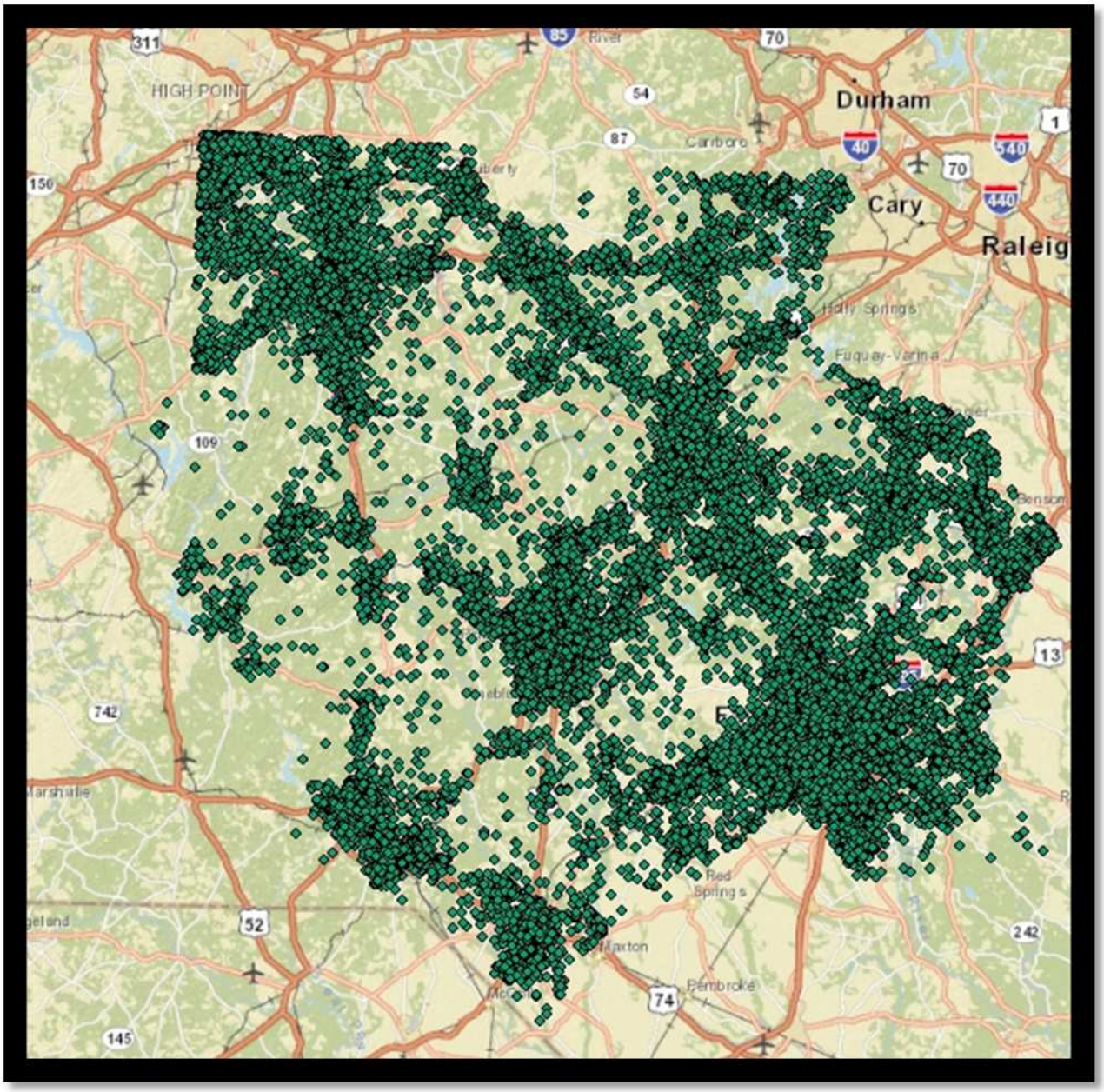


Figure 5: Work Locations in the Moore County Region (Residents and Non-Resident Locations)

By assigning the home and work locations then all other trips can be determined for each mobile device. The following trip purposes were defined in the Moore County data (Figure 6):

- Home Based Other(HBO) – Traveling from Home to Other Locations or from Other Locations back to Home
- Home Based Work(HBW) – Traveling from Home to Work or from Work to back to Home
- Non-Home Based(NHB)- Traveling from a place other than home to another place other than home

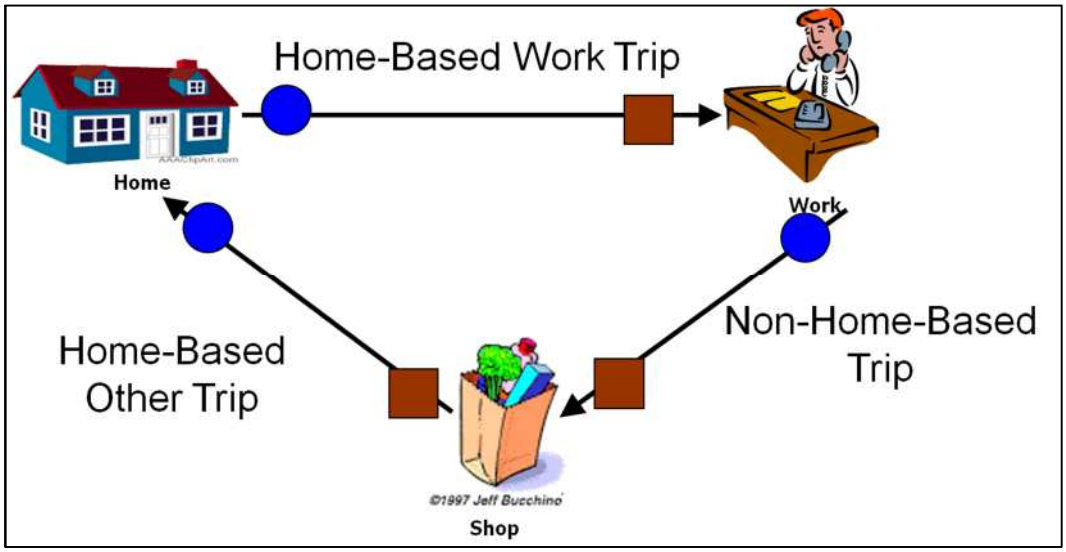


Figure 6: Explanation of the Trip Purposes in the Data

The data also provides the Day of Week the trip was made and during what "time period" the trip was made during the day. Periods are defined as:

- Morning: 6:00 AM to 9:00 AM
- Midday: 9:00 AM to 3:00 PM
- Afternoon: 3:00 PM to 6:00 PM
- Evening / Late Night: 6:00 PM to 6:00 AM

Each trip is assigned an Origin TAZ (beginning of trip) and a Destination TAZ (end of trip) based on the coordinates. An example of the data format is shown in Figure 7.

Origin_Zone	Destination_Zone	Start_Date	End_Date	Aggregation	TripType	Subscriber_Class	Purpose	Time_of_Day	TimePeriod	Count
101	101	20120920	20121018	WD	HBO	Resident	HBO	H0:H6	OP	32.29
101	101	20120920	20121018	WD	NHB	Resident	NHB	H0:H6	OP	5.66
101	101	20120920	20121018	WD	HBW	Resident	HBW	H0:H6	OP	0.87
101	101	20120920	20121018	WD	HBO	Resident	HBO	H10:H15	MD	33.77
101	101	20120920	20121018	WD	NHB	Resident	NHB	H10:H15	MD	8.49
101	101	20120920	20121018	WD	HBW	Resident	HBW	H10:H15	MD	2.6
101	101	20120920	20121018	WD	HBO	Resident	HBO	H15:H19	PM	32.62
101	101	20120920	20121018	WD	HBW	Resident	HBW	H15:H19	PM	1.14
101	101	20120920	20121018	WD	NHB	NonResident	NHB	H15:H19	PM	8.58
101	101	20120920	20121018	WD	HBO	Resident	HBO	H19:H24	OP	32.6
101	101	20120920	20121018	WD	NHB	Resident	NHB	H19:H24	OP	6.08
101	101	20120920	20121018	WD	HBW	Resident	HBW	H19:H24	OP	5.74
101	101	20120920	20121018	WD	HBW	Resident	HBW	H6:H10	AM	3.17
101	101	20120920	20121018	WD	HBO	Resident	HBO	H6:H10	AM	31.62
101	102	20120920	20121018	WD	HBW	NonResident	HBW	H0:H6	OP	1.88
101	102	20120920	20121018	WD	HBO	Resident	HBO	H0:H6	OP	2.61
101	102	20120920	20121018	WD	HBW	Resident	HBW	H10:H15	MD	0.63

Figure 7: Example AirSage Output Data Format

Data Expansion

As indicated, the Trip Count output (across all mobile devices available on AirSage carrier partner networks) represents a sample Trip Count. This sample count represents only a portion of the total population of mobile devices and visitors to the TAZ.

To provide a full population Trip Counts, the sample data must be expanded. This expansion is accomplished using the following:

- Determining the mobile devices' "Home Location" Dividing the mobile device counts for a given "Home" census block group into US Census Population data for the same area yields a "Penetration Factor" – essentially a multiplier to apply to the sample data.

- Optional: If the Trip Count is to report "vehicle" visits, rather than "people" visits, the count must be scaled to reflect average per-vehicle occupancy. Because AirSage counts mobile devices rather than vehicles, multiple occupants present in a vehicle will skew the count numbers higher. Dividing the AirSage mobile device counts by the average vehicle occupancy translates the output to vehicle counts.

- Visibility Factors – how often, and at what intervals, a given device is "seen" by AirSage – are used to tune the expansion algorithms.

5.0 MOORE COUNTY PROJECT SPECIFICS

For the Moore County OD Study 1 month worth of data from Verizon was collected and analyzed. The 20 best days of data September20 to October 18, 2012 were chosen. The data consisted of 8 weekend days and 12 weekdays for a total number of trips recorded of 11,590,819. During the time period 3,017,382 unique mobile ID's were seen at least once in the focus study area. It is important to note that the weekend data is only used to help establish travel patterns like the designation of the home and work locations and to determine the visibility of the device, as discussed previously. The weekend data IS NOT USED when developing the final OD matrix that was used in the analysis of Moore County. Only data for the typical weekday is used and for Moore County that was Tuesday through Thursday data. Figure 8 shows the mobile characteristics by observation date.

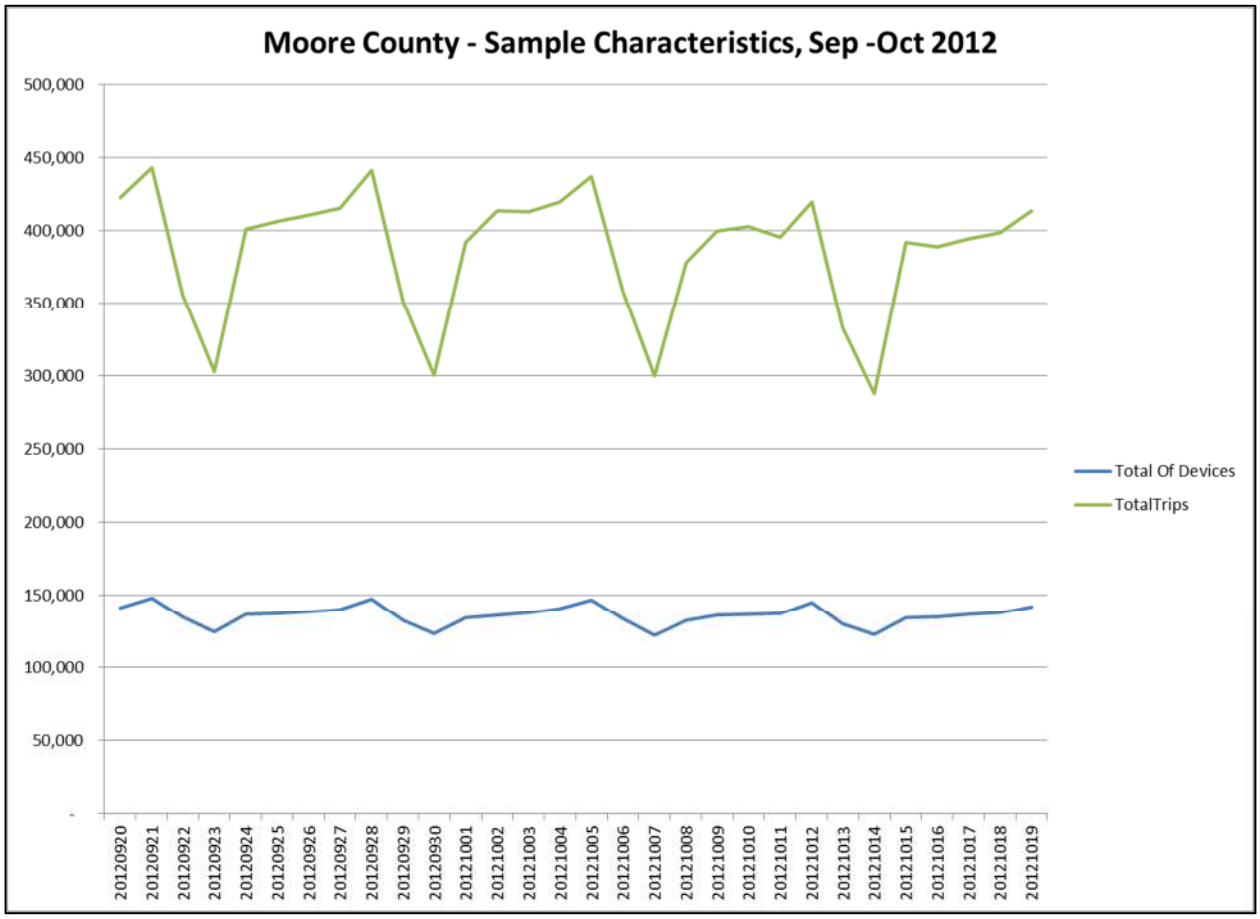


Figure 8: Sample of Mobile Characteristics for Study Period(by Day)

As described previously the data was provided by trip purpose and by resident/non-resident status. In order to better understand the data the study team decided to further refine and clean the data set to provide more insight about the travel patterns in the region.

The team removed Trips Not Really "Through" the region. These were trips that might have gone from Lee County to Chatham county and therefore would never enter into the Moore County transportation network. These trips needed to be removed so that accurate travel patterns could be developed for only Moore County.

The second thing the team did was identify the external to internal trips by residents and non-residents as well as through trips in the region. Figure 9 shows the definition of the trips defined in this step and are described below.

- Through Trips (EE)- Trips in which people do not stop inside Moore County during their trip. The trip began outside of Moore County on one side and continued through without stopping inside the county boundary. An example might be someone traveling from Lee County to Richmond County on US1 through Moore County. These trips are designated by the blue line in the figure.
- External Internal (EI) –Trips in which people start outside Moore County and come to a location in Moore County. They make a stop inside Moore County to shop or work. For example, someone lives in Hoke County but works in Moore County so they come inside the county boundary on a daily basis. These trips are designated by the red line in the figure.
- Internal External (IE)- Trips in which people start inside Moore County and leave the County to get to another location. For example, someone that lives in Aberdeen but works at Fort Bragg so they exit the county boundary to make this trip. These trips are designated by the green line in the figure.

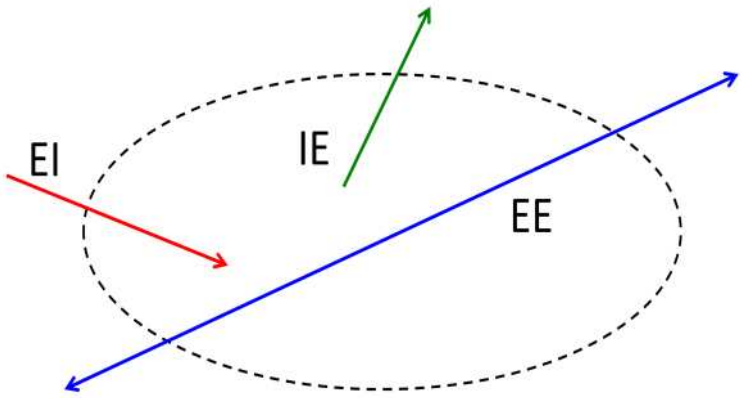


Figure 9: Explanation of External Trip Purposes

Since traffic counts are known at all locations where a road crosses the county boundary, adjustments were made to the IE/EI and EE trips to assure that the ADT control total was correct. That it matched the collected traffic count data at each location.

Once the data was cleaned and processed to get the external trips by resident and non-resident then the data could be used to create a trip matrix. This occurred by using a function to import the database as a matrix. This was done in the TransCAD software platform. TransCad is the software being used to develop the travel demand model for Moore County.

The data from AirSage used the county level outside of Moore County to aggregate those trips. In order to be able to use that data in the TAZ system designated for the model the team had to disaggregate the matrix county level ODs into the Model Stations. That process is not described in this document but it was based on the known ADT counts at each location in the region.

The cleaning resulted in the breakdown of trips in the Moore County region as shown in Figure 10.

Trip Type	Trip	Percentage
Total	378,965	100%
IE_NonResident	6,245	2%
II_NonResident	10,561	3%
II_Resident	274,351	72%
IE_Resident	80,878	21%
EE_Trips	6,930	2%

Figure 10: Total Trips by Type in the Moore County Region

6.0 MOORE COUNTY DATA ANALYSIS RESULTS

The AirSage data was then used to help develop a story of the travel patterns in the region. The details of that analysis are described in this section.

To analyze the data TAZs were grouped into DISTRICTS (larger region). This means that 5-10 TAZs may be grouped into one district so that visualizing and analyzing the data is easier. Figure 11 shows that TAZs 106,107,108 & 109 are grouped together to form district #4(shown in green).

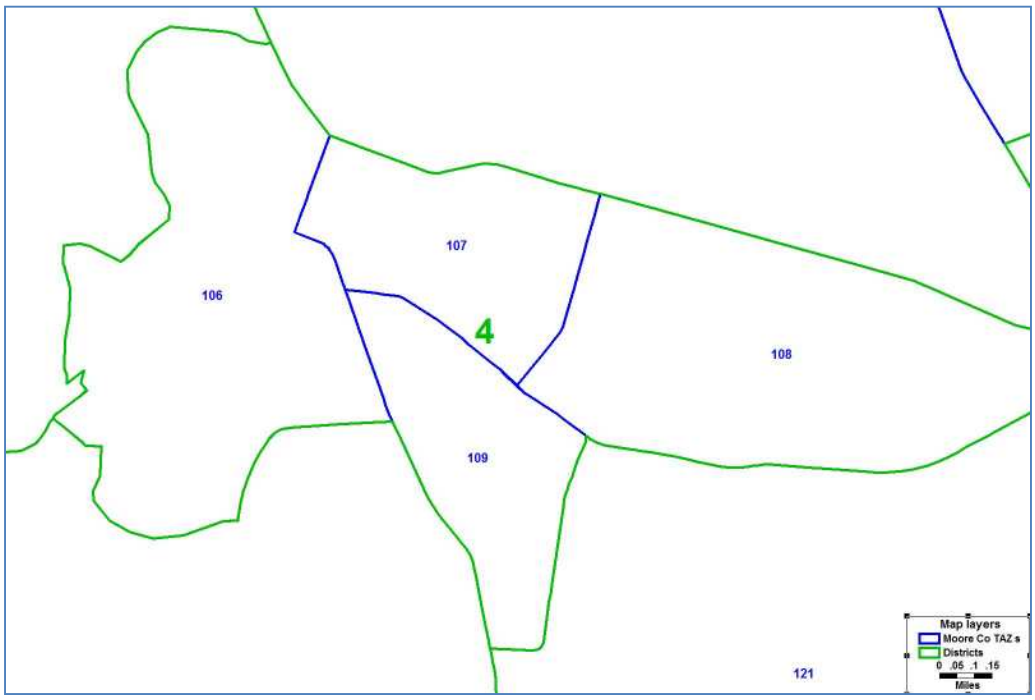


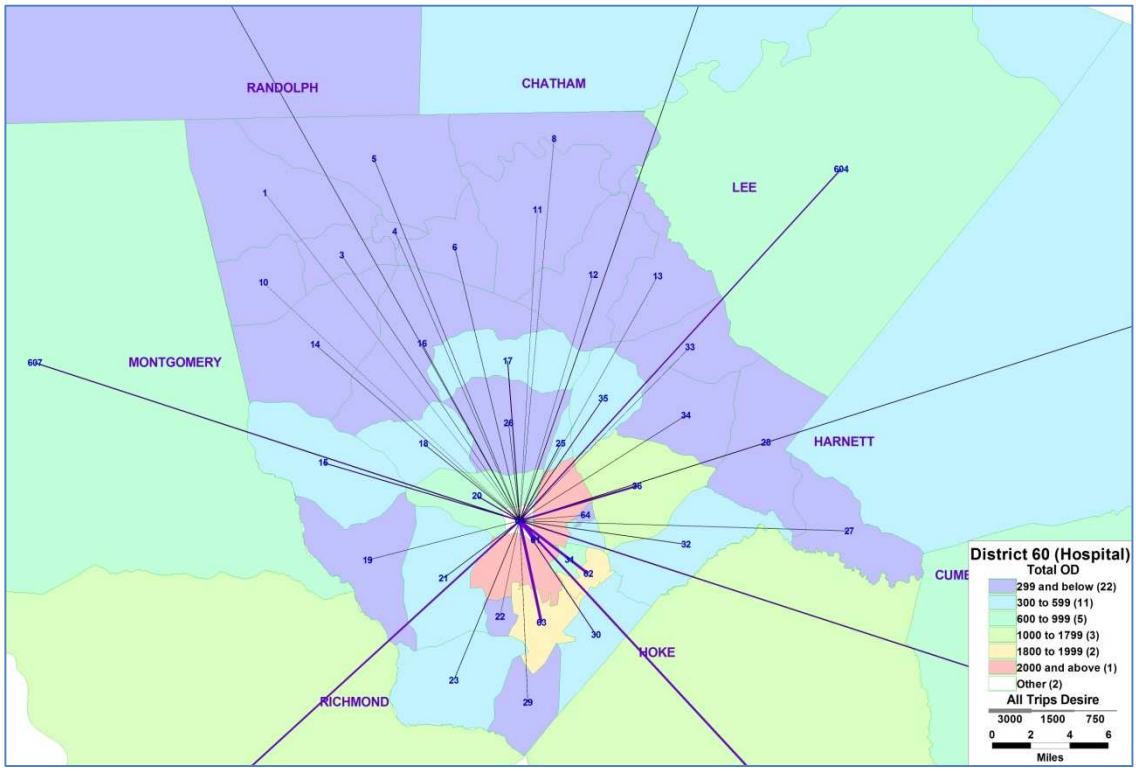
Figure 11: Example of TAZs Grouped into a District

The study team looked at a few key districts to understand the travel flows in Moore County. These districts were created using the TAZs that were directly adjacent to the location mentioned. The districts analyzed were important locations that could easily be logic checked to assure they were telling the proper story. The locations analyzed were:

- The Pinehurst Circle
- US 1 - Southern Pines Corridor (between where US15/501 connects into US 1 continuing northeast to Midland Road)
- The Hospital
- Sandhills Community College

- US 1-Aberdeen Corridor (Along US 1 in between 15/501/NC211 continuing south to the US 1 split with 15/501)

The analysis used "desire lines" which are lines that show the flows between the analysis district and all other districts in the region. For example, for all the people going to the hospital where are they coming from in the region are shown by the lines. The color designation shown for each district on the map is the total daily trips(all purposes) coming from all districts to the district being analyzed.



The Hospital as expected had flows that are not only inside the county but extend way beyond the county into adjacent counties. Given the regional nature of the Hospital this makes sense. Outside the county the largest trip interchanges are from the Hospital ino Hoke and Richmond counties. The flows from the hospital through the circle and into the US 1 corridor are also very high and echo the traffic counts seen in that area(Figure 12).

The flows seen for the Pinehurst Circle(Figure 13) highlight the importance of the flows between this location and the Southern Pines downtown core as well as the connection to the Aberdeen area. It is important to note that the flows extend out in all directions from the circle and even into neighboring counties.

Figure 12: District 60 Hospital OD Flows

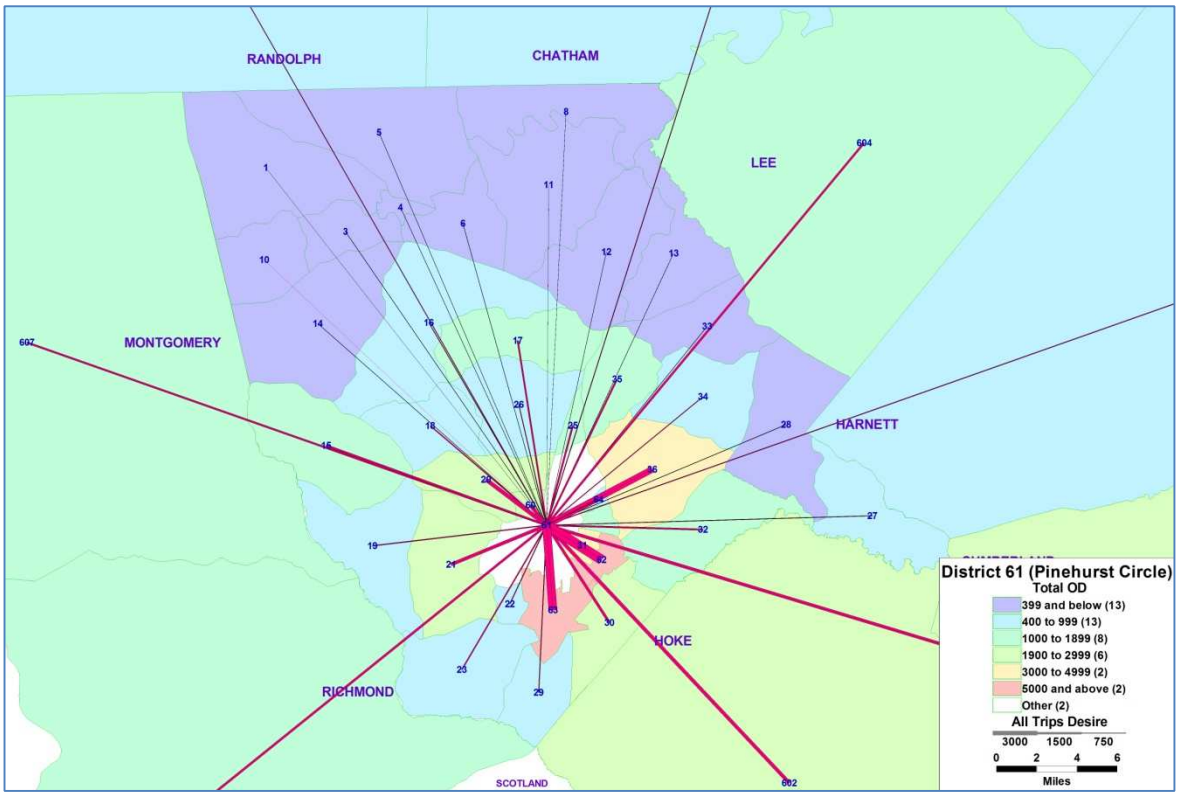


Figure 13: District 61 – Pinehurst Circle OD Flows

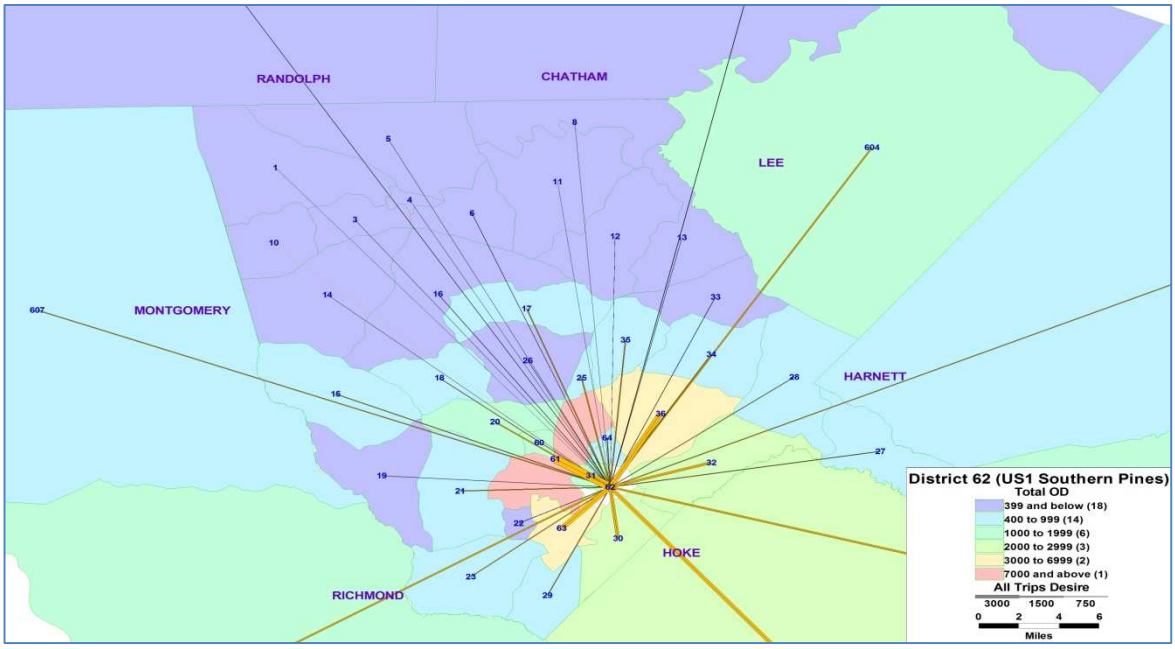


Figure 14: District 62 – US1 Southern Pines OD Flows

The flows shown in the US 1 Southern Pines corridor (Figure 14) section bring attention to the far reaching effects of the flows seen at this location. The major movements are along US 1 to the north and south with both of the adjacent districts over 3000 trips and then over 2000 trips into both Lee and Richmond counties. The major movements into Hoke County also highlight that other flows besides US 1 are important to this section of the county.

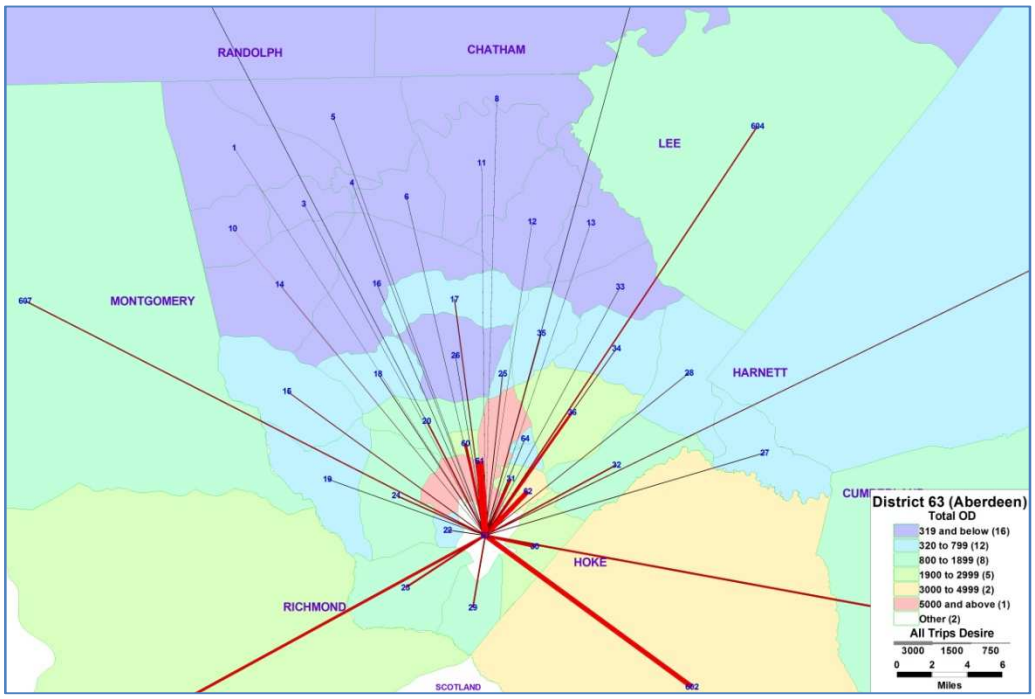


Figure 15: District 63 – US 1 Aberdeen OD Flows

Although the flows going into the community college are a smaller magnitude than the other districts discussed the distances traveled to get to the community college are farther. Most of the districts that have direct interaction with the community college are farther away from this district which would show the major regional influence of the college.

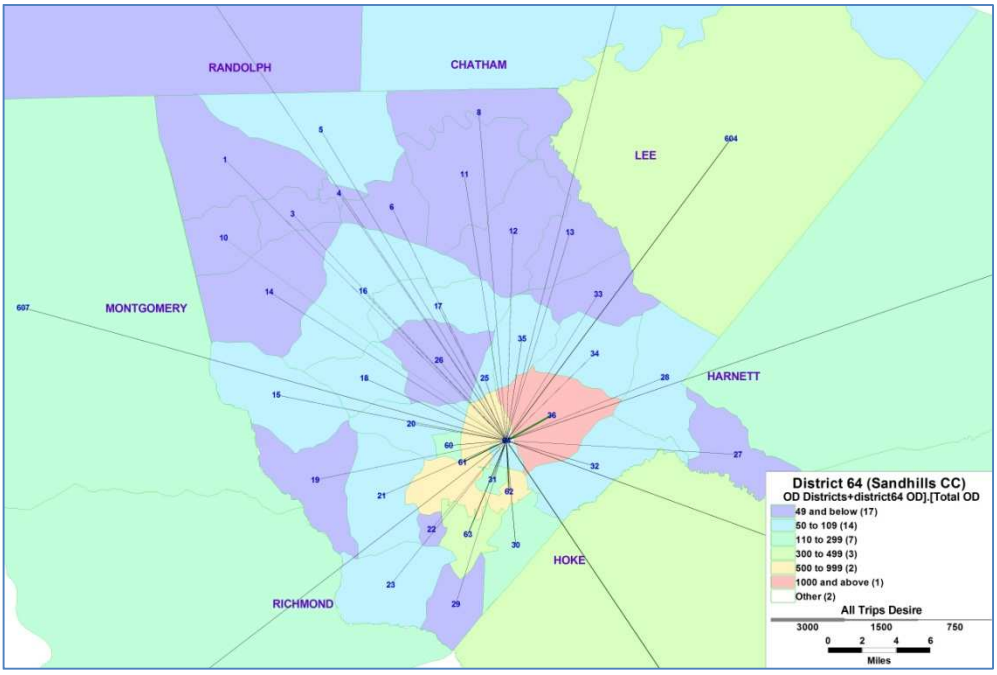


Figure 16: District 64 – Sandhills Community College OD Flows

The previous figures highlight the total trip flows in the region. However, in order to gain complete understanding of the travel patterns it is important to analyze the external trips(trips that leave Moore County) separately from the trips that remain inside the county boundary. As discussed in Section 5, the internal to external trips(and vice versa) are very important to the transportation infrastructure in the county. Figure 17 shows the total EI/IE trips into each district in the region. It immediately becomes obvious that travel from Moore county into both Hoke and Lee county are the highest number of flows. This figure shows that the urban areas in Moore County are attracting people to the area from outside the county.

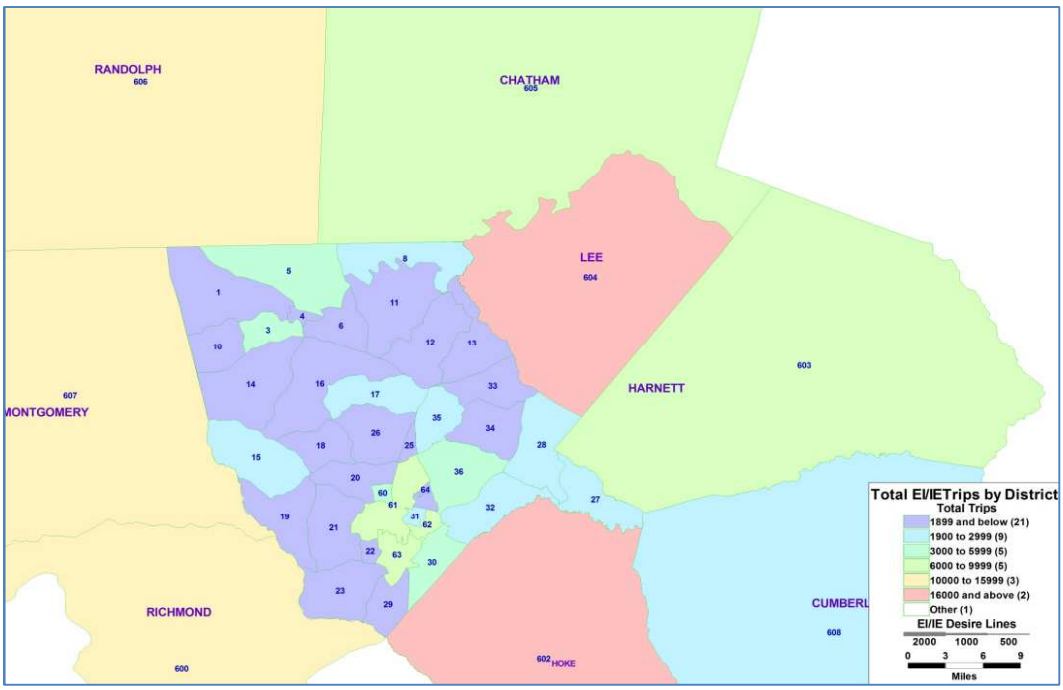


Figure 17: External-Internal Trip Flows

Table 1 shows the total trips going into and out of each of the adjacent counties and the respective percentage of the total external trips. Harnett, Chatham and Cumberland have single digits percentages but the remaining counties get a rather equal share of the trips with the exception of Hoke which has approximately one quarter of the external to internal trips in the region.

County	Total EI/IE Trips	% of EI Trips
Chatham	7,668	9%
Randolph	11,752	13%
Lee	16,852	19%
Montgomery	11,364	13%
Cumberland	2,093	2%
Richmond	10,908	13%
Harnett	6,865	8%
Hoke	19,619	23%
Total	**87,120**	**100%**

Table 1: External Trips by County

The previous figure shows all EI/IE trips in the region but the data is also able to provide more details for each county that surrounds Moore County. Figure 18 and Figure 19 show the flows from the two counties that have the highest number of flows destined for Moore County. Both counties seem to be destined for the heart of the US 1 corridor from Aberdeen to Southern Pines. The other counties are shown in Appendix A.

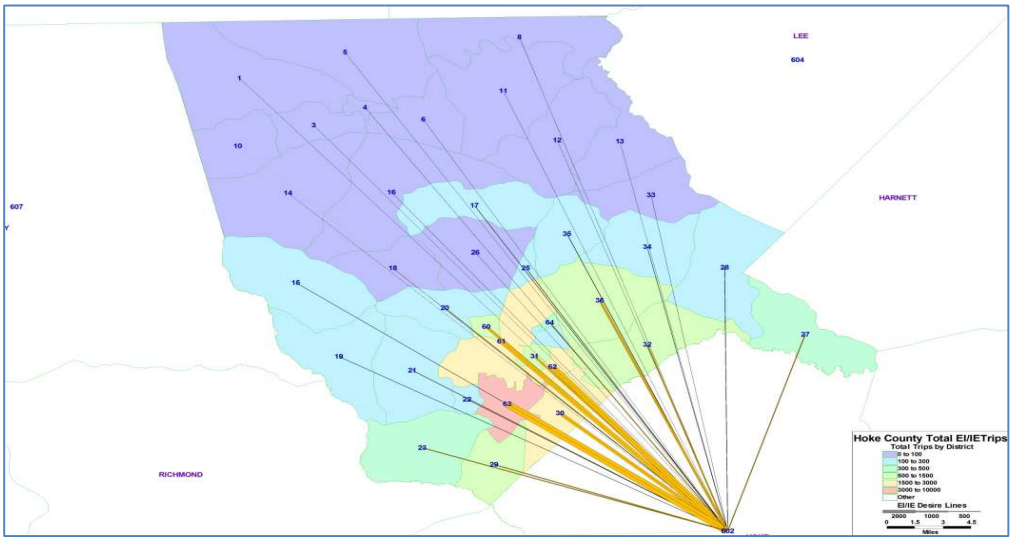


Figure 18: External/Internal Flows from Hoke County

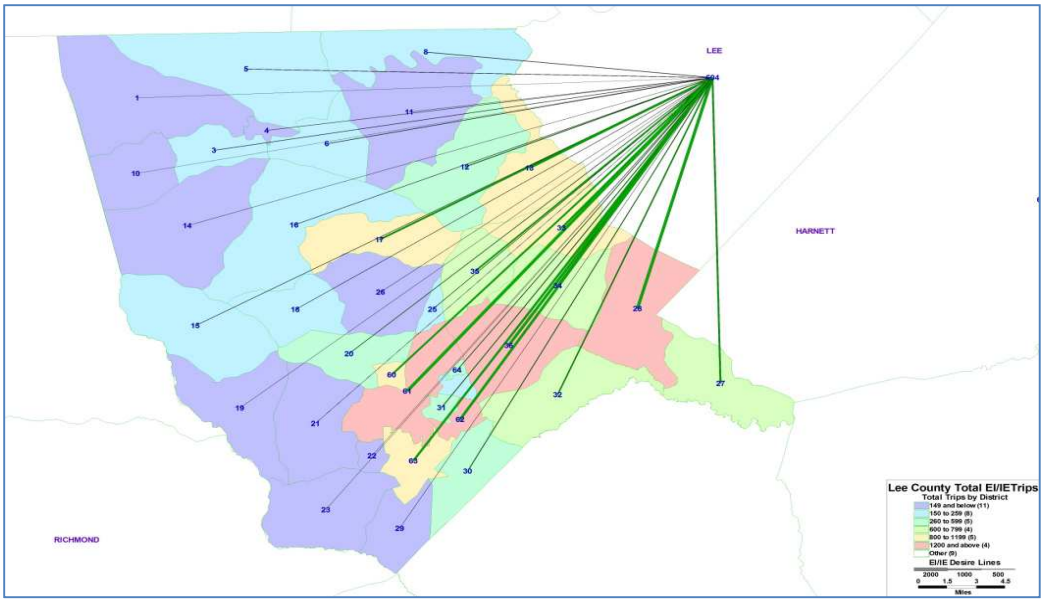


Figure 19: External/Internal Flows from Lee County

External to Internal trips combined with through trips in the region show the longer regional trips. Therefore it is important to understand at a high level the trips that go completely through Moore County. Figure 20 displays the through trips based on the AirSage data. The figure does not explain which facilities are used to travel through Moore County but rather the desire to travel between the counties surrounding Moore.

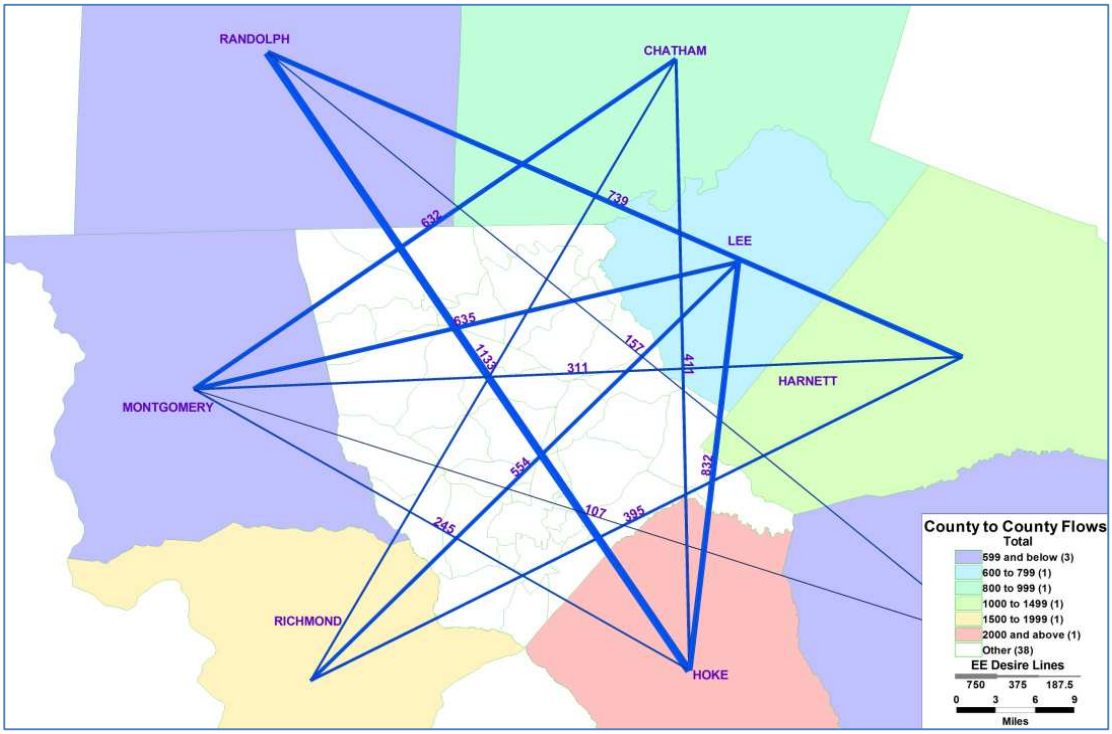


Figure 20: Through Trips in the Moore County Region

Up until this point the data has been used to understand the general flow patterns but it does not provide insight into the roadways used to travel between the districts and TAZs within the region. In order to understand those details a process called “select link” analysis was used. The origin and destination data is assigned to the travel demand model network in order to see which roadways the traffic uses. The model network will be discussed in more detail of the final documentation for the model. The network represents the important roadways in the county, including all US and NC routes as well as other lower level facilities that help to disseminate the traffic in the county. The ODs are assigned using the TAZ level data not the district level data as has been the focus on in other sections.

TransCad software is used to assign the traffic and then key locations are flagged for tracking when the model is operating. By flagging certain roadway segments or points we are able to determine how many vehicles cross that point on a daily basis. In addition it provides the ability to know where each vehicle came from before they crossed that point and where each vehicle ultimately ends up after they cross that point. This means that for every section that is flagged the computer model traces EACH VEHICLE as it moves through network and stores that output.

Figure 21 shows the key locations that NCDOT and Moore County staff selected for analysis.

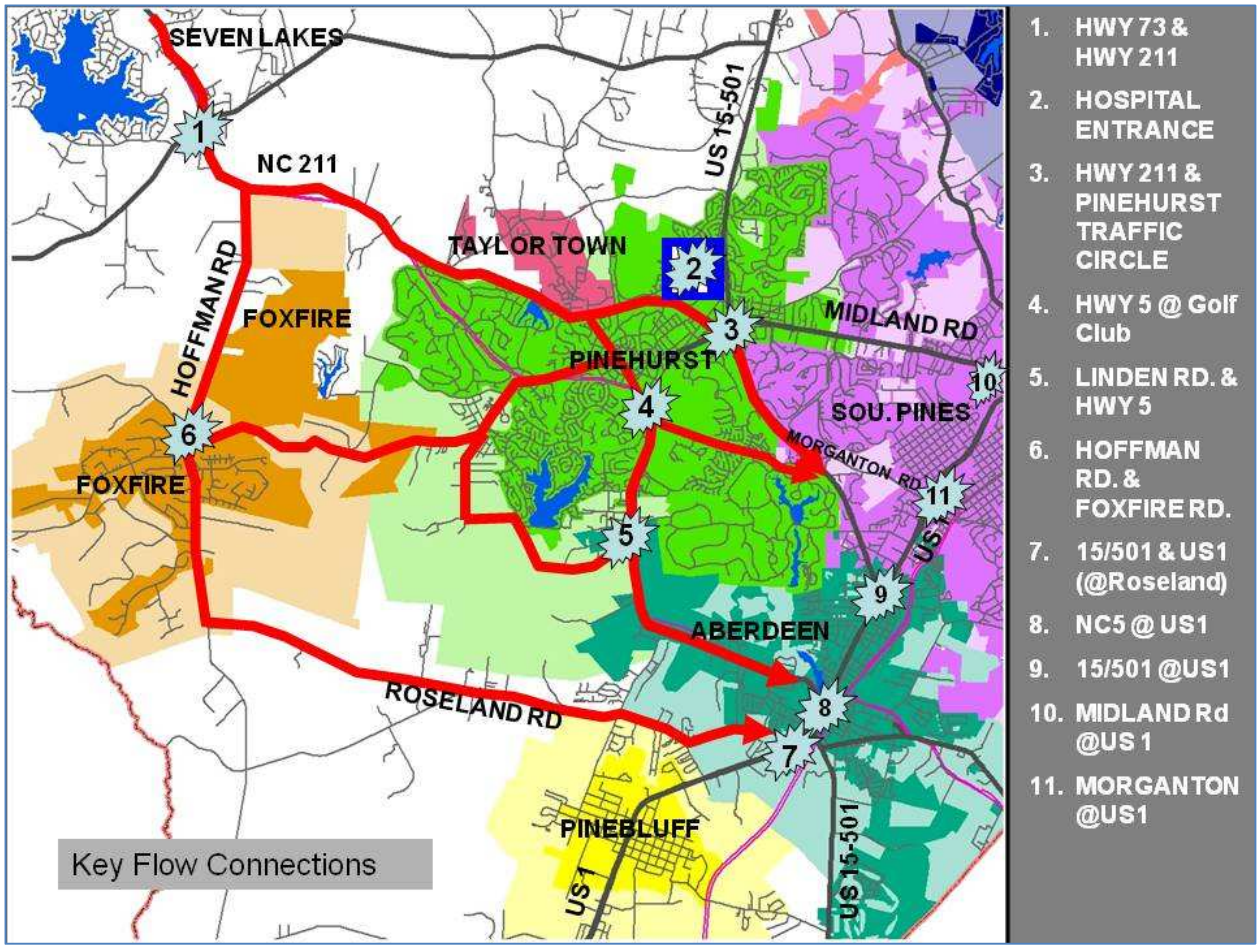


Figure 21: Moore County Select Link Locations

The following maps show the location of all traffic that passes through the ONE critical point noted in the select link map. The only locations shown in this section are site 8 and 9 along US 1. The remaining select link locations are displayed in Appendix B.

Figure 22 shows vehicles passing US 1 at Aberdeen continue their trip south on US1 into Pine Bluff or on US 15/501 towards Laurinburg. Traffic into Hoke County along NC 211 is also a strong movement. In addition, a heavy movement occurs towards the circle as well into Lee County along US 1 to the north.

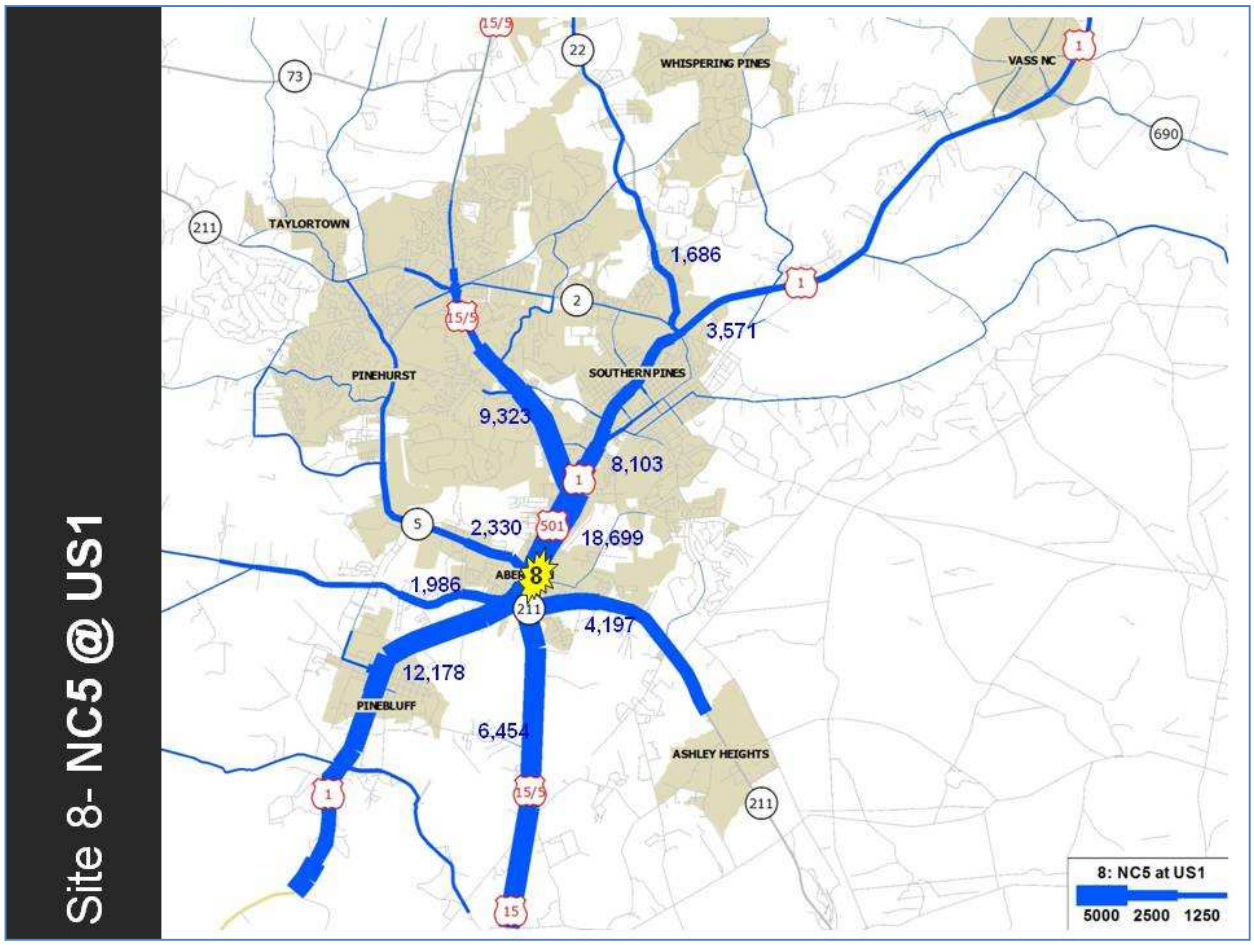


Figure 22: Site 8-US 1 @ Aberdeen

Figure 23 shows similar patterns as Site 8 but has more flow to the North into Lee county and to the west towards the Circle and beyond. These figures highlight just how much interaction there is beyond the immediate vicinity of the select link location.

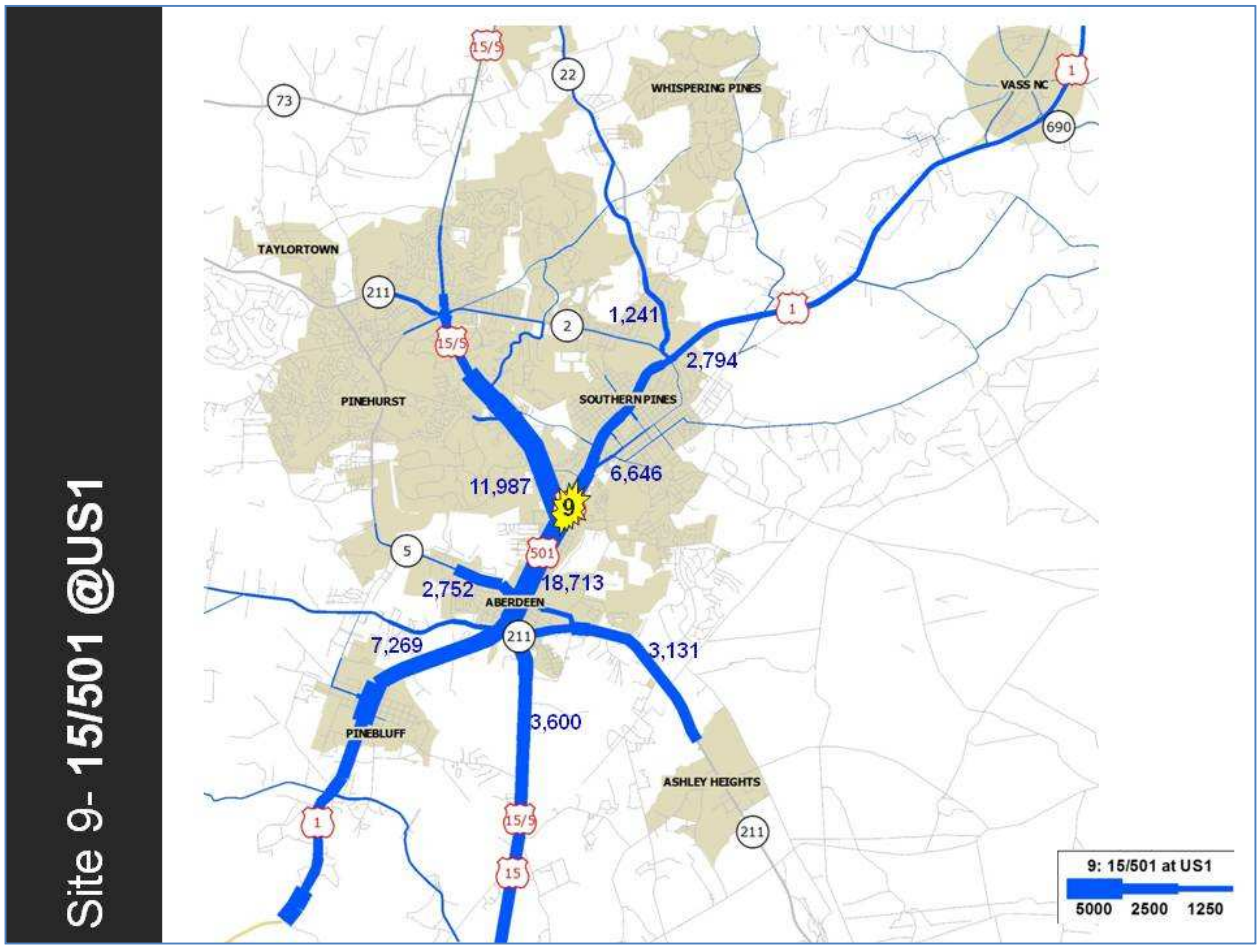


Figure 23: Site 9- On US 1 @ the intersection of US 15/501

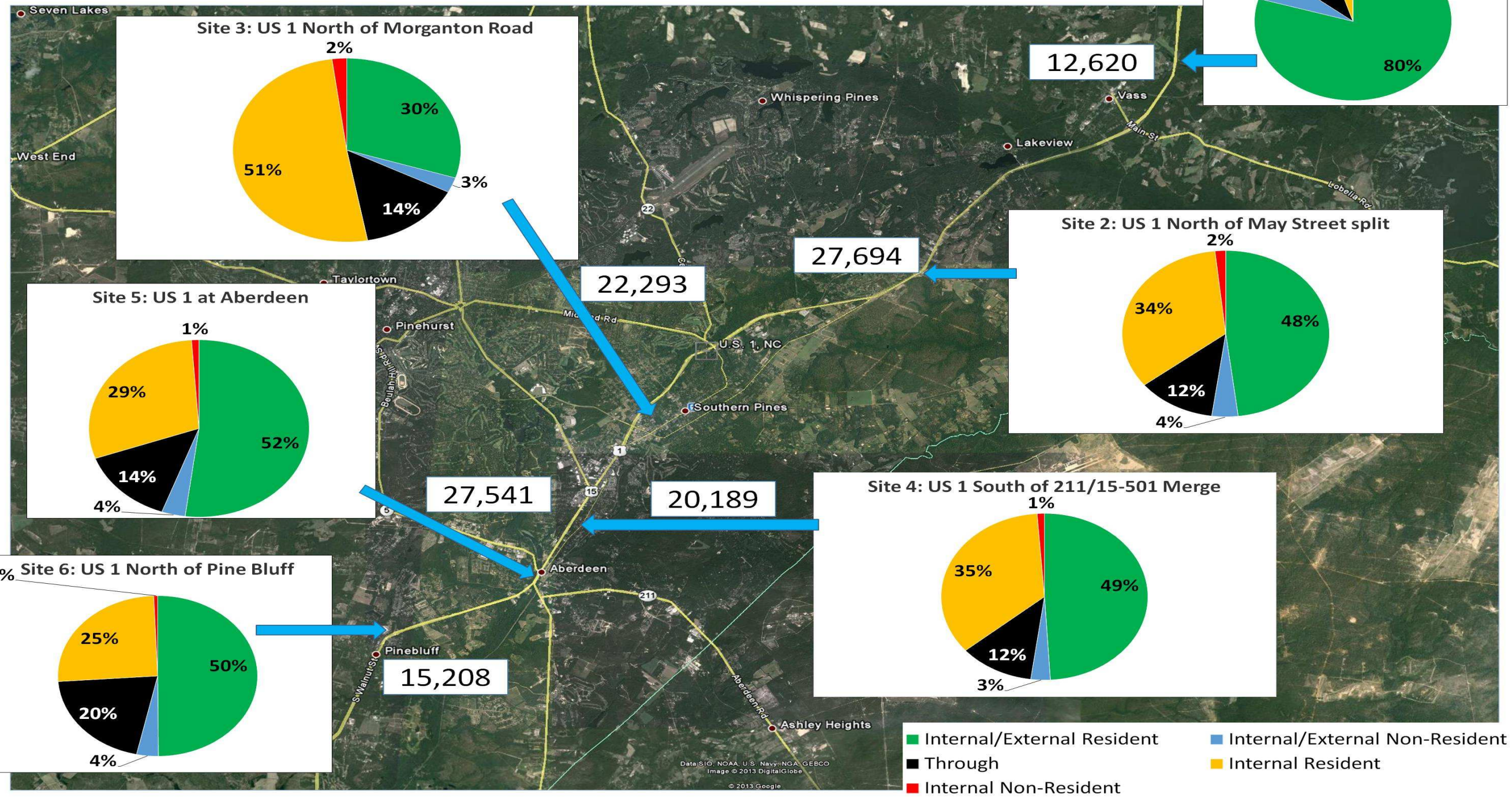
The select link data can also be used for more than total volumes along routes disseminating from the key location. By performing the select link in the travel model software the TYPE of trips along these locations can be analyzed as well. For example, it can be determined:

- How many vehicles on the links are from Moore County residents?
- How many vehicles are from non-residents in other counties?
- How many trips are through trips?
- How many trips stay INSIDE Moore County?
- How many LEAVE the county?

Knowing this information helps to explain the travel patterns along an entire corridor. Figure 24 shows the trips by type at key locations along US 1 in Moore County. The pie charts displayed along the corridor show that only in one location is the internal residents only traffic greater than 50% of the total volume. This can be seen by adding the yellow and red segments of the charts together since they represent trips that remain inside of Moore County. The green, blue and black segments of the charts show the amount of the traffic at that location that LEAVE Moore county during the trip. This analysis provides the MCTC insight into the types of trips that are being made along the US 1 corridor. The percentages are displayed on Figure 24 but the actual volume by type of trip is displayed in

It is important to note that on this figure the total volume listed is not the ADT count at that location but the actual volume based on the OD survey data. It is recognized that a few locations (Site 4 and Site 5) report lower volumes if compared to the 2012 counts taken for these segments. The analysis of the OD volumes at these locations are due to the TAZ size and the loadings of traffic onto the network. Roadway links called Centroids are used to represent the local streets where vehicles access the main facilities in the region. Often times they are positioned initially to represent the center of the TAZ activity but after loading traffic that the centroid is trying to represent to many connections in the TAZ. The locations of these centroids drastically affects the loading on major facilities like US 1 and so additional analysis is needed to refine the location of the access points to better represent the real world access in Moore County. Regardless, the ODs have been shown in many other areas to be within 5-10% of the actual counts which is an outstanding match between datasets. The flows represented still provide invaluable insight into the US 1 travel patterns. This data will be used to calibrate the travel demand model as well as being used when a detailed micro-simulation analysis is performed along US 1 in Moore County.

US 1 in Moore County
OD Flows By Trip Type Using AirSage Data



*Flows are assigned OD's not official AADT's & may not match exact 2013 counts

Figure 24: OD Flows By Percent Trip Type

US 1 in Moore County
OD Flows By Trip Type using AirSage Data

Site Number	Description	Internal/External Resident	Internal/External Non-Resident	Through	Internal Resident	Internal Non-Resident	Total Flow
1	US 1 between Cameron and Vass	10,049	760	1,204	582	25	12,620
2	US 1 North of May Street split	13,315	1,135	3,388	9,397	459	27,694
3	US 1 North of Morganton Road	6,669	593	3,233	11,334	463	22,293
4	US 1 South of 211/15-501 Merge	9,912	612	2,358	7,078	229	20,189
5	US 1 at Aberdeen	14,328	951	3,860	8,104	298	27,541
6	US 1 North of Pine Bluff	7,588	535	3,115	3,875	95	15,208

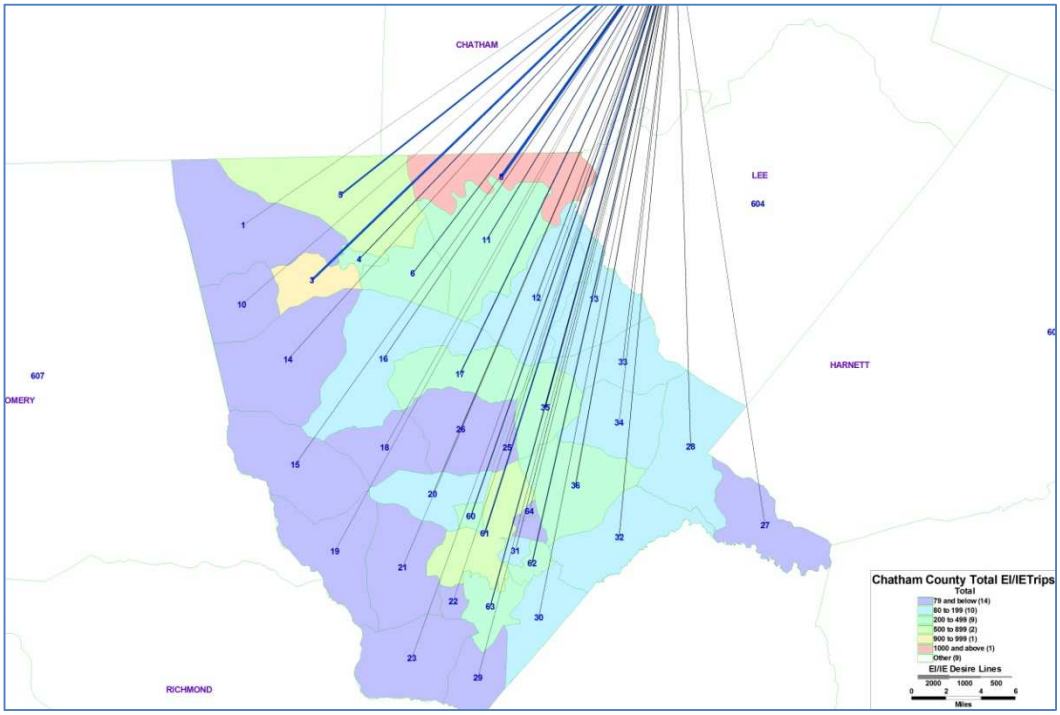
Table 2: Actual OD Flows by Trip Type on US 1

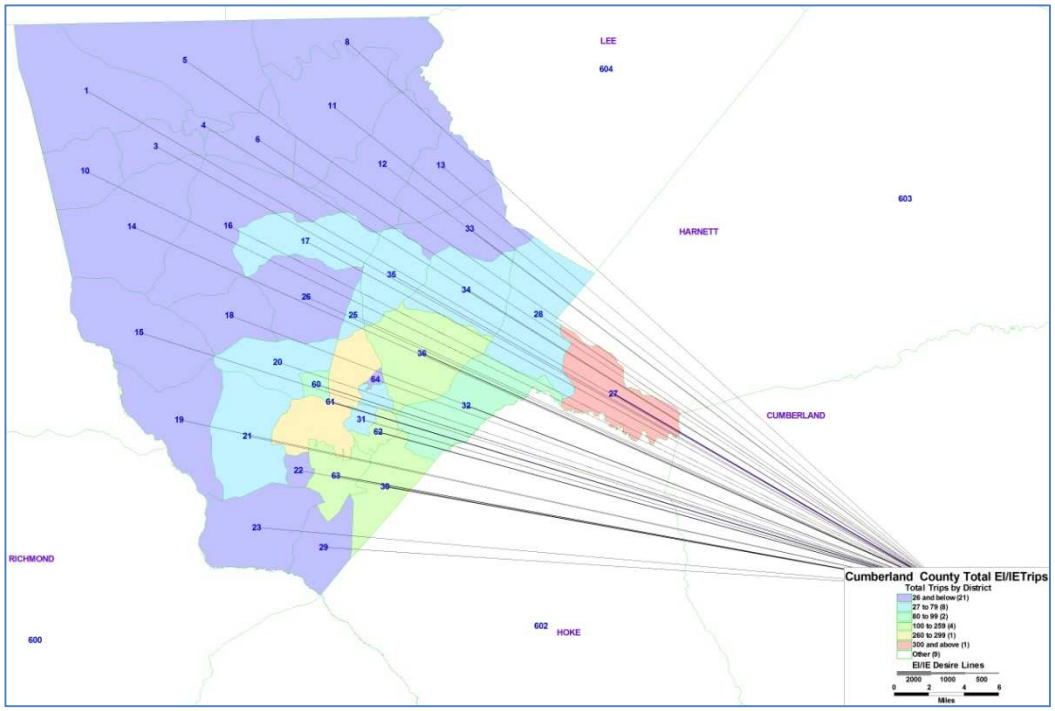
7.0 Summary

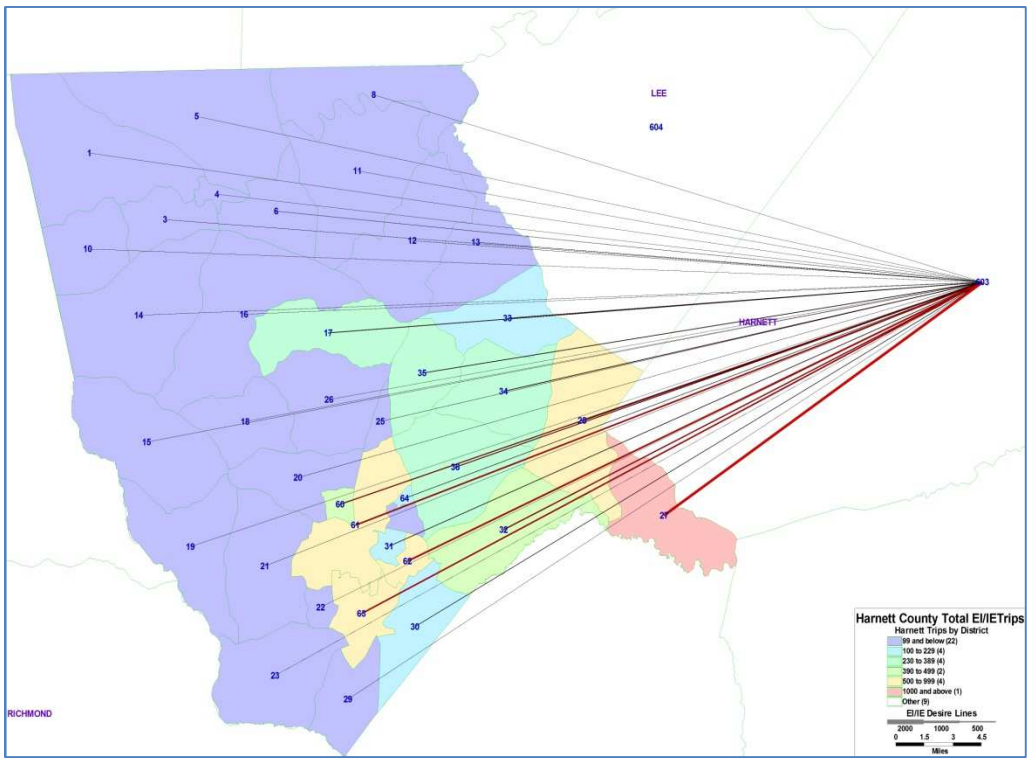
The AirSage data was successfully developed and formatted for use in Moore County in order to help establish a basis of knowledge about travel patterns in the region. This un-intrusive technology allowed for unbiased data to be collected and analyzed. The data is able to logically explain the travel patterns inside the county but more importantly to understand the interaction of the surrounding counties on the transportation system inside of Moore County. The data is able to define high level flows by TAZ and district into and out of the county but also provide detailed insight at the individual link level. The link level insight provides the MCTC with local data that can quantitatively assist in make transportation decisions now and in the future.

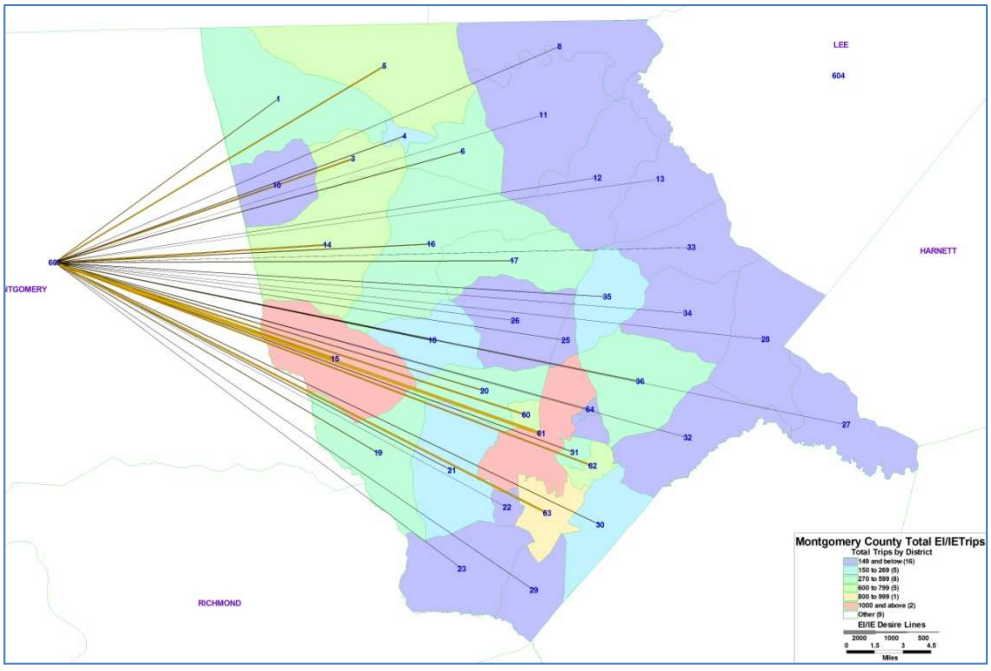
All of the analysis in this document allows for the understanding of all possible travel markets in the Moore County region. In addition the decision to use the cell phone technology provides local data that other areas are not privileged to have during their transportation plan decision process. This data will also be helpful in the calibration of the travel demand model for Moore County.

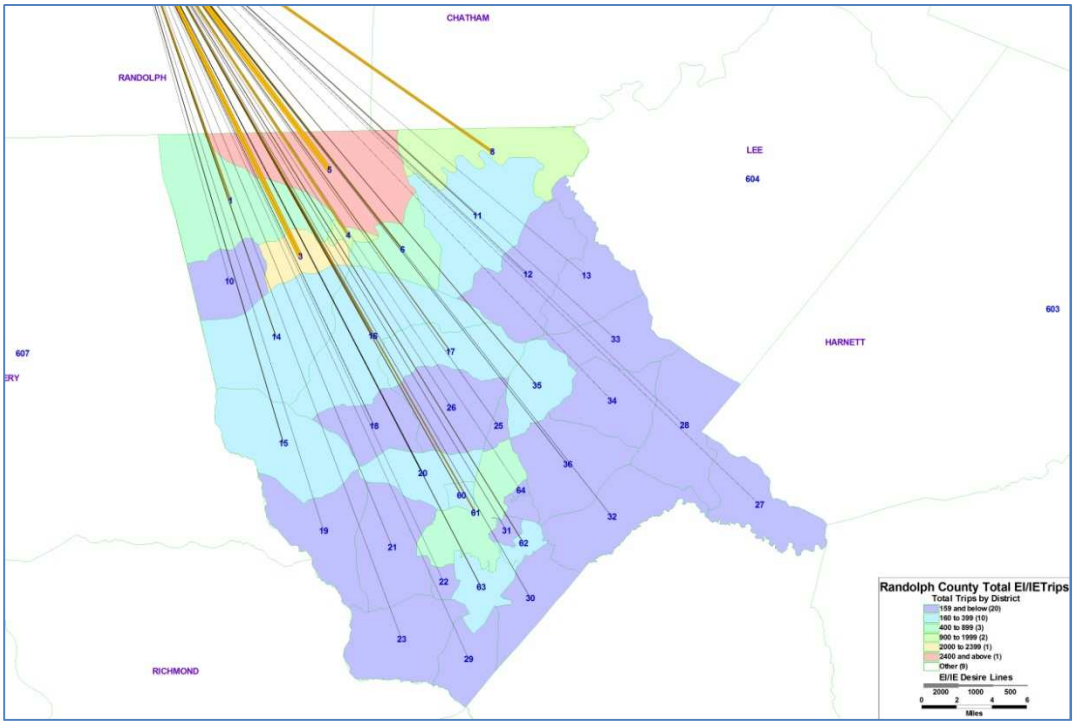
APPENDIX A: Additional External to Internal County Flows





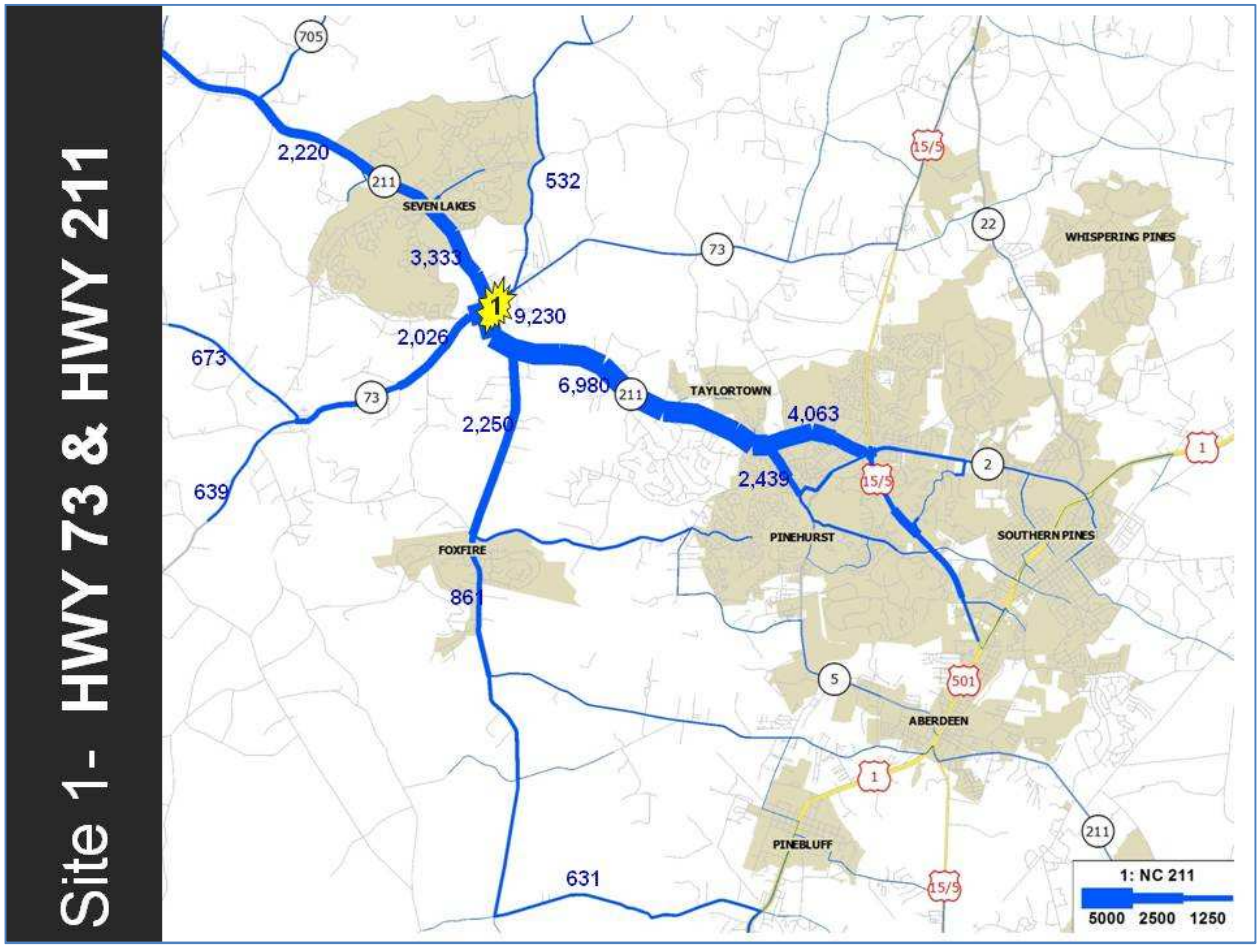

LEE
604
HARNETT
RICHMOND
Harnett County Total EI/IETrips
Harnett Trips by District
99 and below (22)
100 to 229 (4)
230 to 389 (4)
390 to 499 (2)
500 to 999 (4)
1000 and above (1)
Other (9)
EI/IE Desire Lines
2000 1000 500
0 1.5 3 4.5
Miles

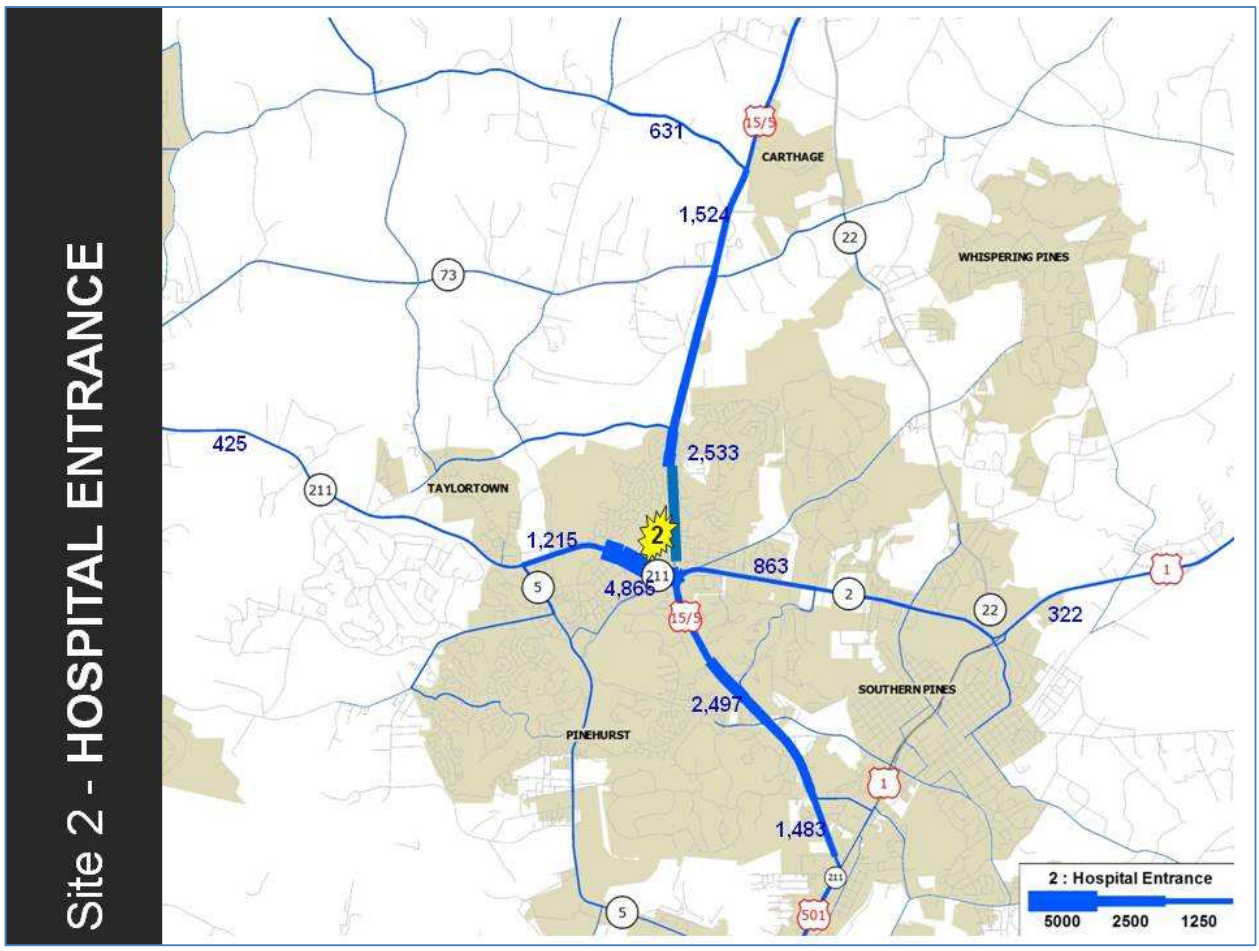

LEE
604
HARNETT
RICHMOND
Montgomery County Total EI/IETrips
Total Trips by District
149 and below (16)
150 to 269 (5)
270 to 599 (8)
600 to 799 (5)
800 to 999 (1)
1000 and above (2)
Other (9)
EI/IE Desire Lines
2000 1000 500
0 1.5 3 4.5
Miles

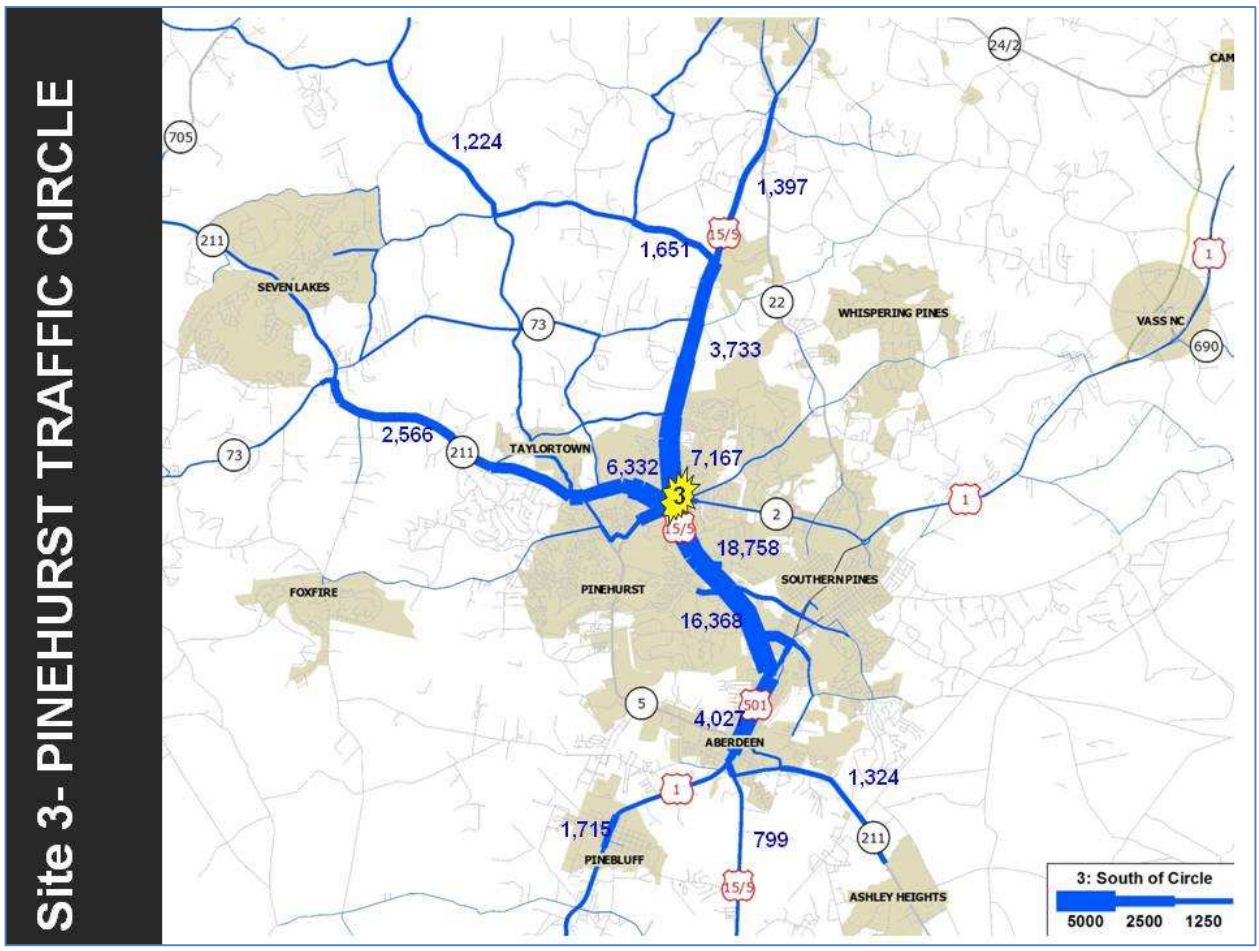

CHATHAM
RANDOLPH
LEE
604
603
HARNETT
607
RICHMOND
Randolph County Total EI/IETrips
Total Trips by District
159 and below (20)
160 to 399 (10)
400 to 899 (3)
900 to 1999 (2)
2000 to 2399 (1)
2400 and above (1)
Other (0)
EI/IE Desire Lines
2000 1000 500
0 2 4 6
Miles

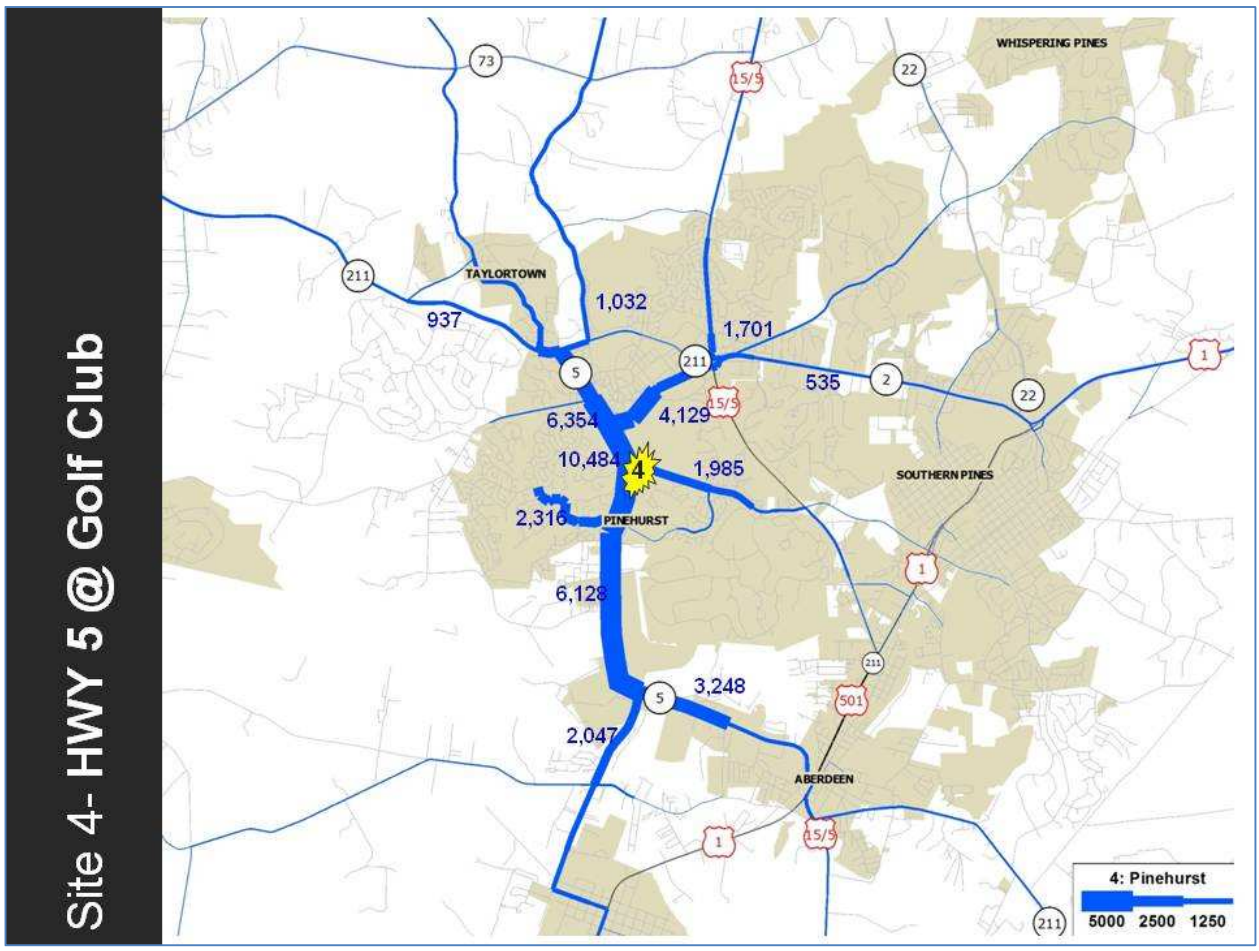

LEE
604
HARNETT
607
RICHMOND
HOKE
602
Richmond County Total EI/IETrips
Total Trips by District
199 and below (23)
200 to 379 (5)
380 to 999 (5)
1000 to 1599 (2)
1600 to 1999 (1)
2000 and above (1)
Other (0)
EI/IE Desire Lines
2000 1000 500
0 1.5 3 4.5
Miles

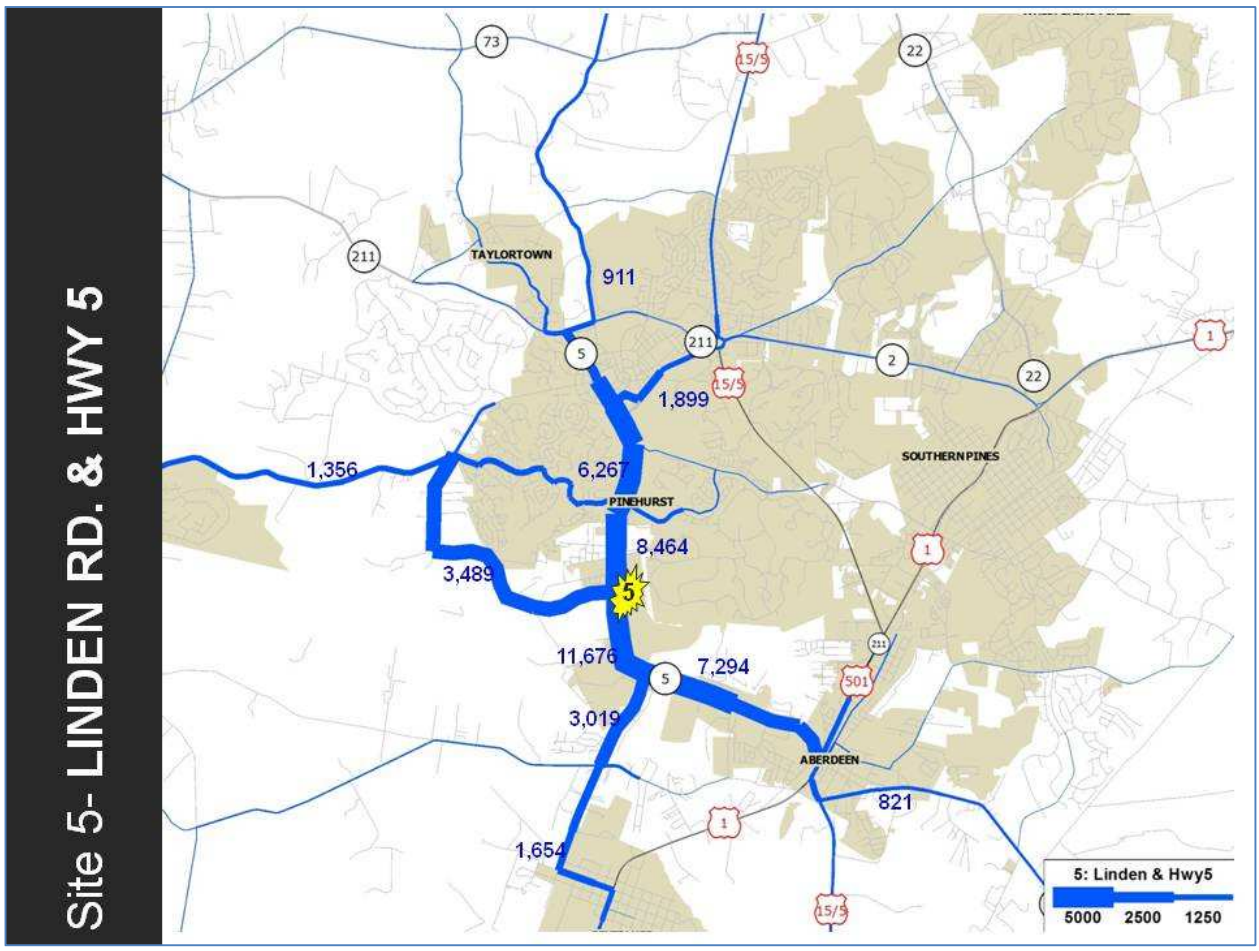
APPENDIX B: Additional Select Link Locations

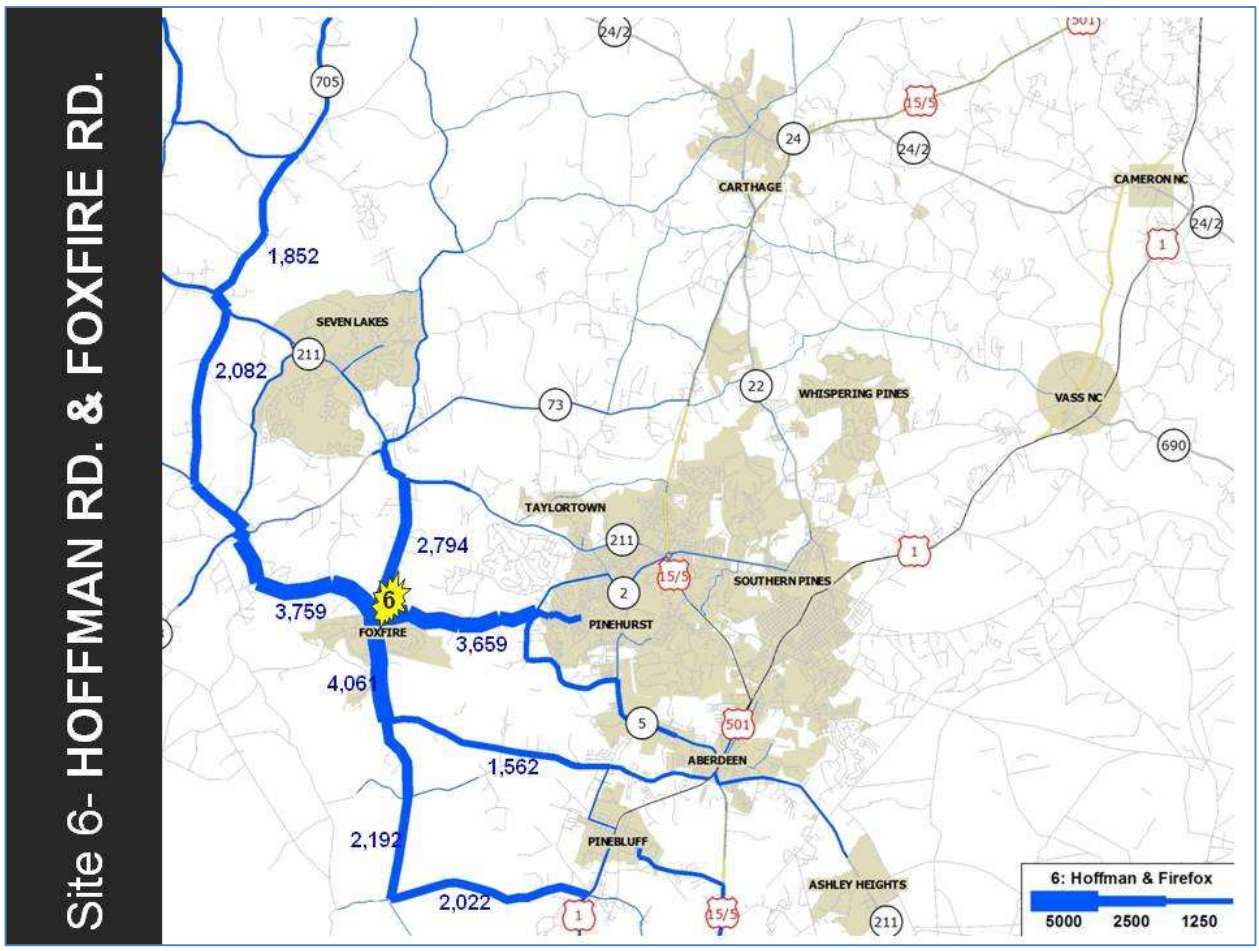


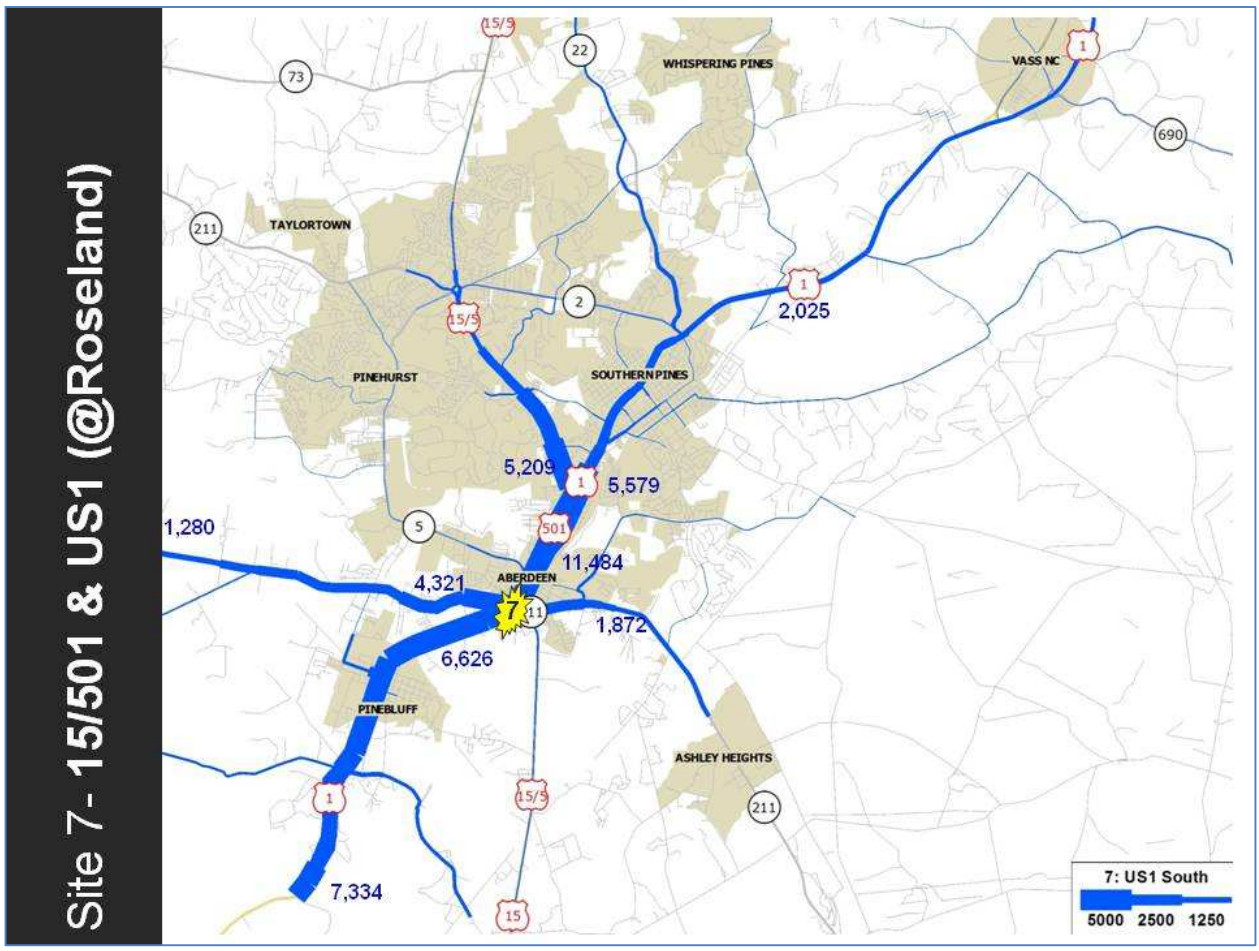

Site 2 - HOSPITAL ENTRANCE
631
1,524
425
2,533
1,215
4,865
863
322
2,497
1,483
CARTHAGE
WHISPERING PINES
TAYLORTOWN
PINEHURST
SOUTHERN PINES
2 : Hospital Entrance
5000
2500
1250


Site 3- PINEHURST TRAFFIC CIRCLE
705
1,224
1,397
211
1,651
15/5
SEVEN LAKES
22
WHISPERING PINES
VASS NC
1
690
73
3,733
2,566
211
TAYLORTOWN
6,332
7,167
3
2
15/5
18,758
SOUTHERN PINES
FOXFIRE
PINEHURST
16,368
5
501
4,027
ABERDEEN
1,324
1
1,715
799
211
PINEBLUFF
15/5
ASHLEY HEIGHTS
3: South of Circle
5000
2500
1250


Site 4- HWY 5 @ Golf Club
WHISPERING PINES
TAYLORTOWN
937
1,032
1,701
535
6,354
4,129
10,484
4
1,985
SOUTHERN PINES
2,316
PINEHURST
6,128
3,248
2,047
ABERDEEN
4: Pinehurst
5000 2500 1250


Site 5- LINDEN RD. & HWY 5
TAYLORTOWN
911
1,899
1,356
6,267
PINEHURST
8,464
3,489
5
11,676
7,294
3,019
ABERDEEN
821
1,654
SOUTHERN PINES
5: Linden & Hwy5
5000 2500 1250


Site 6- HOFFMAN RD. & FOXFIRE RD.
705
24/2
15/5
24
CARTHAGE
CAMERON NC
1,852
SEVEN LAKES
211
2,082
73
22
WHISPERING PINES
VASS NC
690
TAYLORTOWN
2,794
3,759
6
FOXFIRE
3,659
PINEHURST
SOUTHERN PINES
4,061
5
501
ABERDEEN
1,562
2,192
PINEBLUFF
ASHLEY HEIGHTS
2,022
6: Hoffman & Firefox
5000
2500
1250


Site 7 - 15/501 & US1 (@Roseland)
WHISPERING PINES
VASS NC
TAYLORTOWN
PINEHURST
SOUTHERN PINES
ABERDEEN
PINEBLUFF
ASHLEY HEIGHTS
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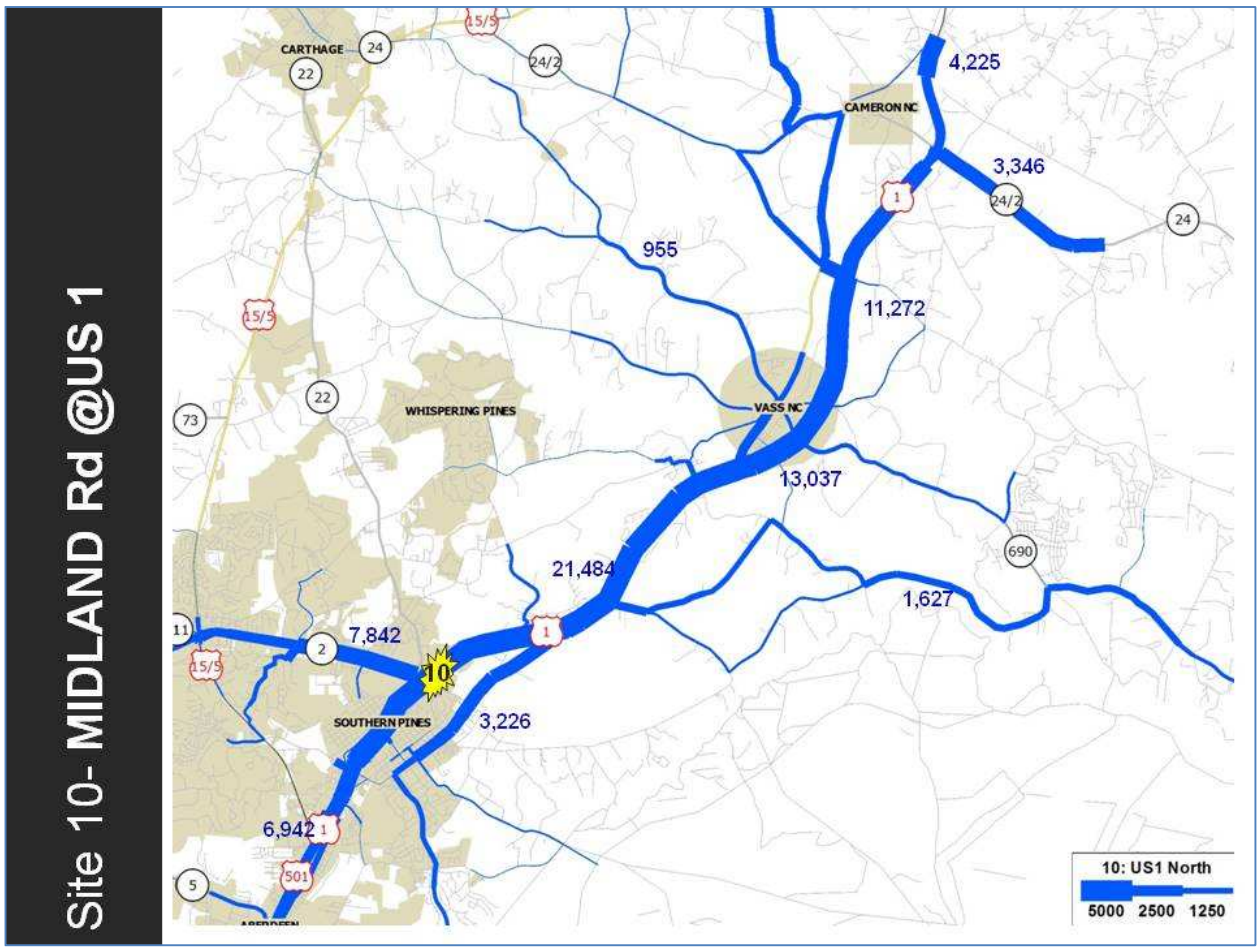
11,484
4,321
1,872
6,626
7,334
7: US1 South
5000 2500 1250


Site 10- MIDLAND Rd @US 1
CARTHAGE
CAMERON NC
WHISPERING PINES
VASS NC
SOUTHERN PINES
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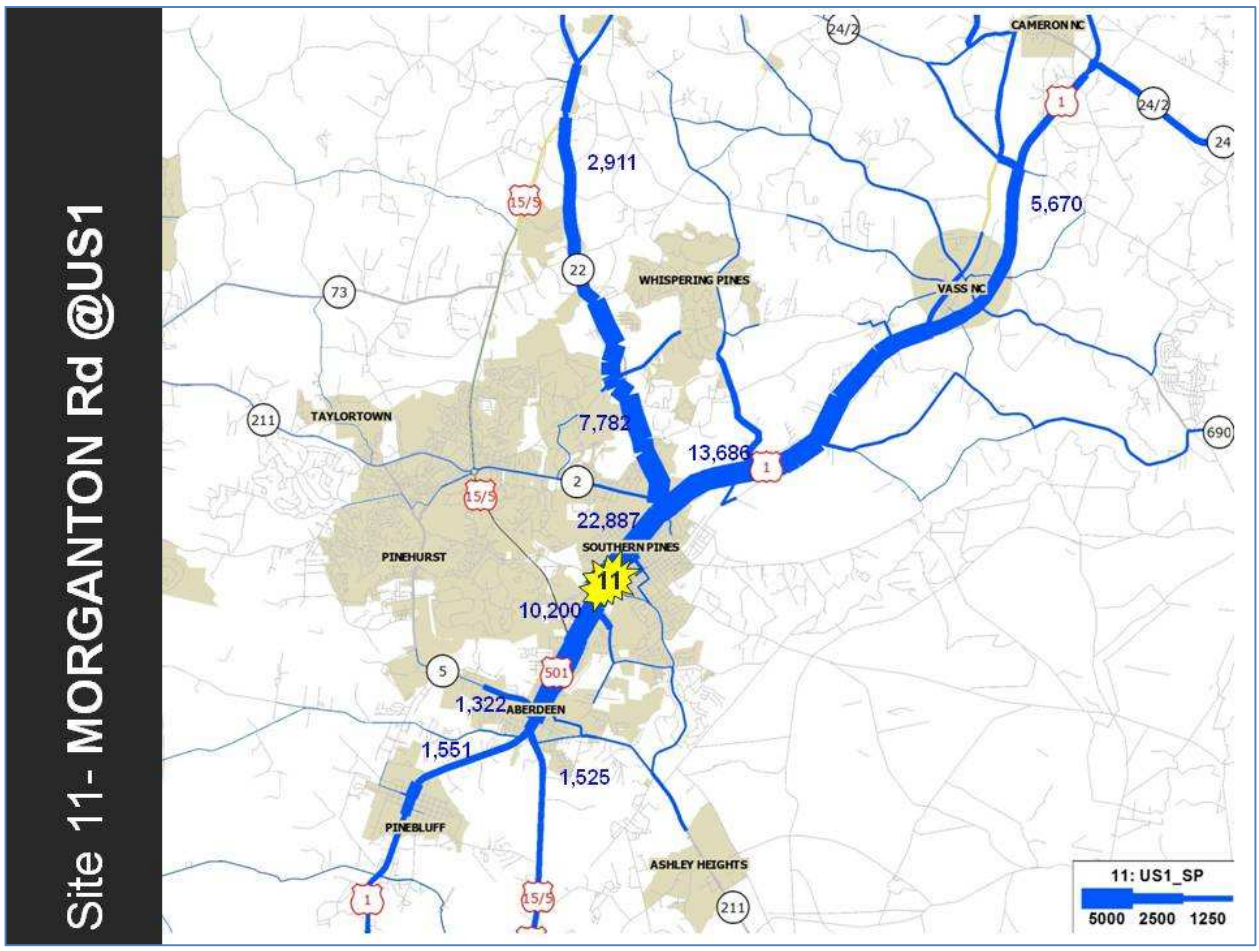
3,226
6,942
10
10: US1 North
5000 2500 1250


Site 11- MORGANTON Rd @US1
2,911
5,670
7,782
13,686
22,887
10,200
1,322
1,551
1,525
11
WHISPERING PINES
VASS NC
CAMERON NC
TAYLORTOWN
PINEHURST
SOUTHERN PINES
ABERDEEN
PINEBLUFF
ASHLEY HEIGHTS
11: US1_SP
5000 2500 1250